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CALIBRATION OF A METAL GAS X-RAY TUBE

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Since the copper target metal gas x-ray tube described by Kersten (5) has been used in numerous biological and biochemical experiments, (1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 20, 21) it was thought advisable to calibrate the energy output of the tube in r-units. Because of its wide application and because no calibration curves for a tube of this type have been published the data was considered of sufficient interest to warrant this paper.

The r-unit output of the tube was determined by means of the standard ionization chamber for soft x-rays described by Taylor (19). Although with this chamber it is usual to collect and measure an electrical charge, the authors elected to measure a charge in motion as an electrical current with the aid of a modification of the feed-back microammeter described by Roberts (15). This method gives an instantaneous indication of the energy output whereas measurements involving an electrometer or any other integrating instrument read only the average output over a period of time and gives its indication only at the end of the period. Such results are averages and are more reproducible than instantaneous readings. For this reason and because with this metal x-ray tube and probably with all other similar tubes it was found that the output was not always the same for a fixed current and voltage input, the results are reproducible only to the extent of plus or minus 10 percent.

The feed-back microammeter may be built by any radio mechanic from parts which may be obtained at a radio supply house for about $35. The ionization chamber may be built by a machinist from brass, Bakelite, and amber insulation costing less than $20. No special skill is required in using the equipment. An added feature of the apparatus is that the meter on which the r-units are indicated may be connected to the rest of the microammeter through a lamp cord of any length so that instantaneous readings of the r-units may be read at the control panel.

The Taylor chamber was used in these measurements because it had been tested and found to be free of errors due to distortion of the electrostatic field in the region of the collector plate. It also has provision for making air absorption corrections which accounts for a large part of its volume. The readings given here are reproducible to within about 10 percent and therefore do not include air absorption corrections. For this reason a smaller chamber might have been used.

The feed-back microammeter and one thousand volt D.C. supply for the ionization chamber were built in a box mounted on one side of the ionization chamber as shown in Fig. 1. The lower appendage shown in the figure provides space for connections between the two units, for the 12J7-GT tube which is mounted in a horizontal position, and for the range selector switch, S-2.

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Fig. 2 shows the circuit diagram of the amplifier. The power is supplied by the 50Y6-GT tube connected in a doubler circuit which permits grounding the negative side of the rectifier output. With such a circuit it is necessary to have the A.C. power line connected in the correct manner so that a pilot light is provided as an indicator. Incorrect polarity on the power cord will cause the light to burn when the case of the microammeter is grounded. If the lamp lights the plug should be reversed immediately in its receptacle. The selector switch S-2 is provided so that a large range of r-units may be measured on the same instrument. If R-1 is made 60 megohms, a full-scale reading on the O-30 microammeter will be 3 r-units per second or 180 per minute. If R-1 is 30 megohms the full-scale reading will be 6 r-units per second or 360 per minute and so on. This ratio will hold for values of R-1 in the range of from 0.1 to 100 megohms.

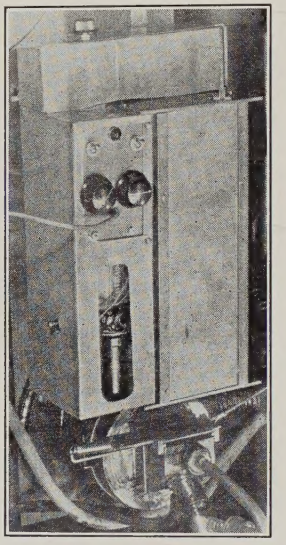

Figure 1

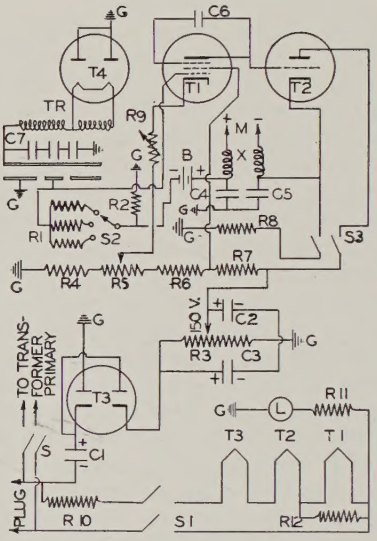

Figure 2

Fig. 1. Photograph showing the ionization chamber and combined feedback amplifier and power supply in position below the x-ray tube window.

Fig. 2. Schematic diagram of the amplifier and power supply. T-1, 12J7-GT; T-2, 12SF-5-GT; T-3, 50Y6-GT; T-4, 5W4; TR, Power transformer, 700 volts; 5 volts, 2 Amp.; R-1, see text; R-2, 2000 ohm precision non-inductive resistor; R-3, 25000 ohm 10 watt Dividohm; R-4, 500 ohm, ½ watt; R-5, 1000 ohm potentiometer; R-6, 20000 ohm, ½ watt; R-7, 120000 ohm, ½ watt; R-8, 50000 ohm, ½ watt; R-9, 1000 ohm potentiometer; R-10, 320 ohm Cordohm; R-11, 200 ohm, 10 watt; R-12, 150 ohm, ½ watt; C-1, 16 mfd. 250 volt; C-2, 16 mfd. 250 volt; C-3, 16 mfd. 400 volt; C-4, .01 mfd. mica; C-5, .01 mfd. mica; C-6, .01 mfd. mica; C-7, three 8 mfd. condensers in series; X, 80 millihenry chokes; M, 0-30 microammeter; B, 22.5 volt B-battery; S, DPST toggle switch; S-1, DPST toggle switch; S-2, 3-position selector switch; S-3, DPST toggle switch, L, 2.5 volt, ½ amp. pilot lamp; G, grounded to case.

Best results will be obtained with this instrument if it is operated from a stabilized A.C. source. If the x-ray apparatus is equipped with a magnetic stabilizer which will supply 115 volts with one of the lines grounded, the amplifier may be connected to it. Otherwise it may be supplied through a separate 25 watt stabilizer. The fact that the zero setting, which is controlled by the potentiometer and rheostat R-5 and R-9, may drift very slowly while readings are being taken is of no consequence since all measurements should be made as a difference of two readings; one with the x-rays entering the chamber and one with the x-rays cut off.

We consider one bit of information derived from these tests to be of considerable interest. As mentioned, it was found that the energy output for a gas x-ray tube of this type operated at a constant voltage and current is not constant. Two

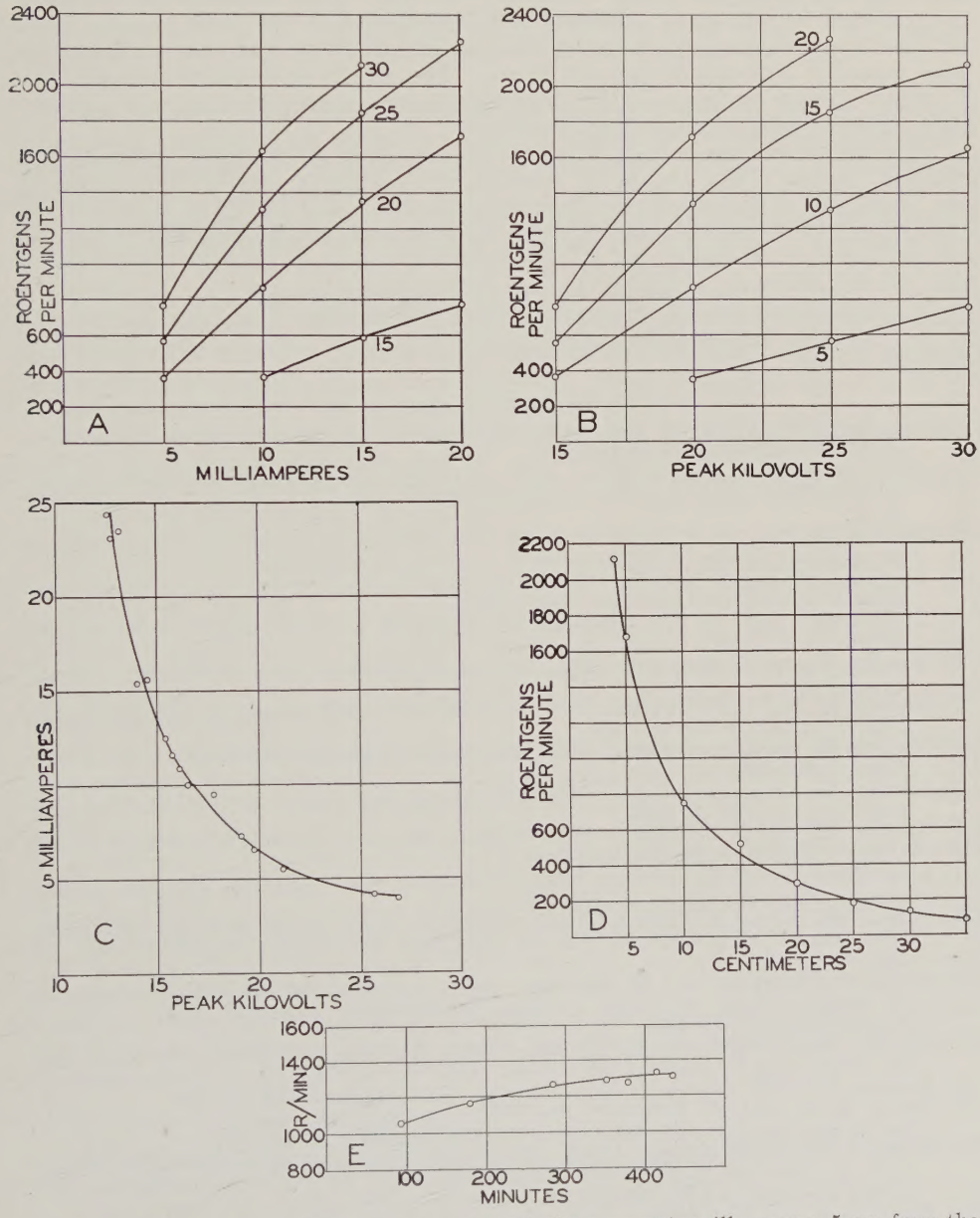

FIG. 3. A, Roentgens per minute as a function of tube current in millamperes, 5 cm. from the tube window. The numbers next to the curves indicate peak kilovolts. B, Roentgens per minute as a function of peak kilovolts, 5 cm. from the tube window. The numbers next to the curves indicate tube current in milliamperes. C, Tube current as a function of peak kilovolts for a constant output of 635 r per minute, 5 cm. from the tube window. D, Roentgens per minute as a function of distance from the tube window when the tube was operated at 30 peak kilovolts, 10 millamperes. E, Roentgens per minute as a function of time elapsed after initial evacuation. 20 peak kilovolts, 15 milliamperes.

types of change in output at constant input have been observed. The first of these is a gradual increase in output as the tube is used. A test was made to illustrate the phenomenon. The tube was opened to atmospheric pressure by removing the Cellophane and aluminum window. New windows of the same material and of the same thickness were installed and the tube pumped until sufficient vacuum was established to take readings at 20 kv. and 15 ma. Readings were taken at intervals for several hours. The results were plotted in Fig. 3E. Therefore, before readings for the other figures were taken the tube was operated for a sufficient time to insure their constancy.

The second change in output was noted to occur occasionally and is of the following nature. For any given voltage and current in the ranges shown in Fig. 3A-D the r-unit output may decrease to as little as one-third of that given in those figures. As yet the cause for this has not been established but it can be pointed out that in this design the anode almost surrounds the cathode and therefore all the electrons indicated by the milliammeter do not need to strike the anode in the usual focal spot position above the window. The data given in the figures therefore represent the maximum output, which is also the usual output, of the tube.

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NEWBERRY ON THE OHIO DRIFT

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This is a study of one aspect of scientific method, of error in science. Science is a growth, a series of approximations; as it advances some old views are discarded, new views introduced. The discarded views are seen in the light of fuller knowledge to be in error. Inadequate approximations would be a better characterization; they were the best formulation the earlier science could make. To use the word error is not to condemn; it is merely to acknowledge that advance has since been made.

The theories of an individual geologist, for example, are conditioned by the state of the science at the time, by opportunities for and skill in field observation and laboratory practice, even by personal bias and idiosyncracies. This makes the study of the history of science interesting. It is not merely that at a certain date a geologist held certain views; it is "how he got that way."

An interesting example of views held mid-course in the developing science of glacial geology is Newberry's[1] account of the glacial drift of Ohio. This was followed three years later by a second report which marks a distinct advance.[2] We deal here primarily with the first account.

Newberry was one of the ablest geologists of his day. He had wide experience in the field, and was well acquainted with geological literature and with contemporary geologists. His work in glacial geology was done in the Lake Erie region, his home in youth, to which he returned for detailed field study when head of the Geological Survey of Ohio. Two things should be said: one, that Newberry's primary interest was not glacial geology but stratigraphy and paleontology, and the other, that the Lake Erie region is one of great complexity, so far as its glacial history is concerned.

In 1870 glacial geology was little more than thirty years old. In 1837 Agassiz had outlined the whole subject of Alpine glaciation in masterly fashion. He had gone on in the years following to plaster immense ice sheets, far greater than we now know ever existed, over Europe and America. This was an advance in theory which most geologists found it difficult to follow. Previous to Agassiz geologists had explained the general lowland drift of Europe and America as deposited by icebergs during a period of continental subsidence. Lyell still held to the iceberg hypothesis at the time Newberry was writing. In considering the thinking of any geologist in 1870 it is necessary to keep in mind the prevalence of the iceberg hypothesis at that time, and also that when glacier work was in question it was valley glaciers of the Alpine type which was in mind. Further, almost no attention was then given to the composition of the glacial deposits themselves.

GLACIAL HISTORY OF OHIO

A brief summary of the glacial history of Ohio as worked out by Leverett[3]

[1]Newberry, J. S. Geological Survey of Ohio, Part I. Report of Progress in 1869, pp. 24–33. 1871.

[2]Newberry, J. S. Geological Survey of Ohio, Vol. II, Part I. Geology, pp. 1–80, 1874.

[3]Leverett. Glacial Formations and Drainage Features of the Erie and Ohio Basins. U. S. Geol. Survey, Monograph 41. 1902.

H. P. Cushing, Frank Leverett and Frank VanHorn. Geology and Mineral Resources of the Cleveland District, Ohio. U. S. Geol. Survey Bull. 818. 1931.

and others will give the necessary background for an understanding of Newberry's history of the same region. The history at present accepted is as follows:

1. An earlier ice-sheet and drift, the Illinoian.
2. An interglacial ice-free period.
3. A later ice-sheet and drift, the Wisconsin.

Both sheets crossed the present St. Lawrence-Ohio divide, and covered large parts of Ohio. The Wisconsin glacier did not extend as far south as the Illinoian, so that a belt of older drift borders the Wisconsin drift in central and southern Ohio. The older Illinoian drift is found in places under the Wisconsin drift, sometimes separated from it by a soil or forest layer; but in most places the Wisconsin ice swept away the earlier drift. This separation of the Pleistocene into two and later more periods was not made until after Newberry's work.

4. After the Wisconsin glacier had withdrawn north of the divide, a series of temporary ice-dammed lakes formed between the glacier and the divide. The story of this period is long and involved. Retreats and advances of the ice opened different outlets across the divide, and the lake levels changed with these shifting outlets. Land uplift to the northeast, the center of ice accumulation, complicated matters still more. In these lakes laminated clays were laid down; about their borders beaches, bars and cliffs were formed; and over the bottoms which were bared as the levels dropped, sands were washed from the adjacent lands. This sketch makes no provision for any water bodies in the region caused by subsidence.

NEWBERRY'S SUMMARY

Newberry's history[4] may be summarized as follows:

I. Ice-period; 1–3 (of Newberry's account).

A period of high land and cold climate with the development of "glaciers which flowed by various routes to the sea."

II. Water period.

4. A water period in which the continent stood 500 feet or more below its present level, and the glacier was replaced in the basin of the Great Lakes by an inland sea of fresh water. In this sea "were deposited the fine, laminated clays (Erie clays) which cover so much of the glacial surface in the interior of the continent."

5. Deposition on the Erie clays of sand, gravel and boulders floated by icebergs from the glaciers of the north.

6. Silting up of the old preglacial valleys.

III. Period of continental emergence.

7. Clearing out of old channels.

8. Periods of repose during elevation, permitting river terracing and the formation of shore features at lower and lower levels above the present lake surface.

9. Redistribution by waves and streams of material over surfaces newly exposed by recession of the sea.

For 1870 this is a remarkably skillful presentation of glacial history, especially when we recall that it has taken scores of workers through seven succeeding decades to bring our knowledge to its present state, and that a lot yet remains to be known. Good as it is, it contains errors, our interest in which lies in knowing how they came to be.

THE GLACIERS

Newberry's first period is one of high land level, during which glaciers formed, and "following the direction of the great lines of drainage" flowed to the sea.

[4]Loc. cit., pp. 28–33. 1871.

Newberry speaks of glaciers, not *the* glacier. In 1870 it was still the Alpine type of valley glaciation that dominated the thinking of the geologist. Little was known of the Greenland glacier, and no clear appreciation of the immense ice sheets of the Pleistocene had yet been reached. More remarkable is his statement, "the direction of the glacial furrows proves that one of these ice rivers flowed from Lake Huron along the channel now filled with drift . . . into Lake Erie . . . following the line of the major axis of Lake Erie to near its eastern extremity; here turning northeast this glacier passed through some channel on the Canadian side, now filled up, into Lake Ontario, and thence found its way to the sea, either by the St. Lawrence or by the Mohawk and Hudson." The glacial furrows do in general parallel the axes of the Great Lake basins, for these troughs were pre-glacial valleys which locally directed the flow of the ice sheet. But Newberry has the direction reversed for Erie and Ontario! It is easy to see how a preconception in favor of the Alpine valley type of glaciation was carried over into the quite different topography of the broad lowlands of the Great Lakes region. But the direction of flow? One would suppose that a careful study of the glaciated surfaces must have shown that the direction of flow in each basin was to the southwest and not to the northeast. That study was not made, the glaciers had to get to the sea, and theory controlled.

Both of these mistakes Newberry soon corrected.[5] By 1874 he had concluded that at the time of maximum glaciation "a great ice-sheet was formed." "Local glaciers" in the valleys were limited to the beginning and closing stages of glaciation. (This holding to valley glaciers is less surprising when we see how the lobes of the Wisconsin ice sheet pushed forward in the larger river basins.) The ice was seen to flow southwest through Ontario and Erie, and the frontispiece of the 1874 report is a beautifully engraved plate, showing the curving grooves about chert concretions on the glaciated limestone surface which definitely fix the direction of the ice motion.

POSTGLACIAL SUBSIDENCE

Newberry's period of land elevation and glaciers is followed by a period of submergence, a "water period when the continent was depressed 500 or more feet below its present level . . . when glaciers retreated northward and were gradually replaced, in the basin of the Great Lakes, by an inland sea of fresh water." Newberry probably considered this water body to be at sea level. Lake Erie is 573 feet above sea level, and a depression of 500 feet or more might bring the region to direct communication with the ocean. In the 1874 report[6] subsidence permitted the northward extension of the Gulf of Mexico until it "reached and covered all the lower portion of our State." This was clearly overdoing the subsidence, for which there is no evidence. Not wholly unreasonably, for there was clear evidence of postglacial lower land levels in the upper Hudson and St. Lawrence valleys, and there was a lot of lake water in the Erie basin. The hypothesis of water origin of the drift should have suggested search for independent evidence of a marine water body in the character of the drift, in marine fossils, in shore lines. That it did not was due to the uncritical acceptance of the current theory of drift origin.

ERIE CLAYS AND GLACIAL TILL

Let us recall that there were ice barrier lakes north of the St. Lawrence-Ohio divide. Within their former area are found laminated lake clays. South from the highest lake beach to the divide and beyond to the southern limit of the drift, the characteristic surface deposit is an unstratified boulder clay or till of direct ice deposition.

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[5]Geological Survey of Ohio, Geology II, pp. 77–80. 1874.

[6]Loc. cit., pp. 7, 79.

Now Newberry's most serious error was his failure to recognize the boulder clay as ice laid and his inclusion of it and the lake clays in one unit (the Erie clays of Sir Wm. Logan), regarding them as deposits in an inland sea. He describes the Erie clays as "generally regularly stratified in thin layers and containing no fossils but drifted coniferous wood and leaves. Over the southern and eastern part of the lake basin these clays contain almost no boulders, but toward the north and west they include scattered stones, often of large size, while in places beds of boulders and gravel are found resting directly upon the glacial surface. They reach up the hillsides more than 200 feet above the present surface of Lake Erie." In Cuyahoga County[7] he reports them to 500 feet above Lake Erie (more than 200 feet above the highest lake ridge). Where the clays are cut by the tunnel to the water crib "occasionally are found in the clay . . . rounded, striated boulders, two, three and four inches in diameter." Clearly Newberry includes in his water laid Erie clays typical glacial till, and carries them far higher than and well south of the margin of the former glacial lakes, indeed so far as to include all the glacial drift of the state.

There are several reasons for this error. Faulty or inadequate observation, which includes a lack of appreciation of the physical make-up of the deposits themselves, is the basal reason. Scattered rounded and striated boulders embedded in unstratified clay does not look like water deposition. Perhaps with the still lingering iceberg hypothesis in mind it was easy to explain the boulders as carried by floating ice. Further, the presence of occasional layers of sand and gravel at all levels in the till may have been misleading. Nor was it always easy in the field to separate till from the overlying lacustrine deposits. The marine laminated clays, Champlain clays, laid down in the Hudson-Champlain and St. Lawrence valleys during the lower land levels of the early post-glacial period, were considered identical with the Erie clays by Newberry. The upshot was that a water laid origin which was good for the lacustrine clays was carried over to the till; and confusion was the result.

ICEBERG TRANSPORT OF GLACIAL ERRATICS

Newberry states that "upon the stratified clays, sand and gravel (i. e., his Erie clays) of the drift deposits are scattered blocks of all sizes, of granite, greenstone (diorite and dolerite), siliceous and mica slates, generally traceable to some locality in the Eozoic area north of the lakes. . . . Most of the stones are rounded by attrition. . . . That these materials were not carried by currents of water or glaciers is certain; as either of these transporting agents would have torn up the Erie clays, which now form an unbroken sheet beneath them. We are therefore forced to the conclusion that they were floated to their resting places, and that by icebergs."

Presumably this statement applies to all the erratics of the glacial area, both within the area of the former lakes and beyond to the southern limit of the drift. It fails to explain the boulders buried in the drift. It indicates lack of careful field study of the erratics, and it requires a standing water body over the whole of the drift area of Ohio. The subsidence-iceberg hypothesis still biased Newberry's thinking.

NEWBERRY'S LATER VIEWS

Newberry's second 1874 report is a distinct advance on the earlier one. He recognizes the presence of a continental ice sheet; the only influence of the valley glacial notion is his retention of valley glaciers in the closing stages of glaciation. The direction of ice motion in the Erie and Ohio basins is corrected.

[7]Newberry, J. S. Geological Survey of Ohio, Vol. I, Part I. Geology, 1873, p. 175.

A main advance is in the clear recognition of ice barrier lakes, instead of pauses in land uplift as explaining the succession of lake ridges.

Little advance, however, is shown in the understanding of the drift. He states that much of the drift or boulder clay was the direct marginal or submarginal deposit of the glacier in its northward retreat, but still lumps till and laminated lake clays in one "Erie clays," and gives the whole a water origin. He still holds to the transport of the erratics by icebergs. There is no real understanding of the till or of the relation of the boulders to the till.

The above discussion is not to be taken as in any sense a disparagement of Newberry's work; but rather as a study of the way in which geological science is advanced by the individual worker. He builds on the work of his predecessors, sometimes on their errors. By his own field work and thought he corrects some of these errors and adds new material. He, like them, is subject to the human chance of error in observation and reasoning, against which no one is immune. His published results bring the matter out into the open for discussion and criticism by fellow workers. His errors can be challenged by other facts unknown to him. His statements may suggest other studies, which may or may not corroborate his views. And so science advances by a process of trial and error, ever working toward a more truthful generalization. In all this Newberry ran true to form. More than many he corrected his own mistakes.

Livestock Breeding

The third edition of this well-known text is a thoroughly scientific up-to-date treatise on the principles of reproduction and genetics which underlie the art and practise of livestock breeding. The author has attempted to bring together in one volume the material which the agricultural student gets all too smatteringly in courses in zoology, physiology, and anatomy: material on reproductive physiology, mammalian embryology, genetics of farm animals, animal hygiene and the like. In this attempt the author has succeeded admirably. Following an interesting account of the historical background of livestock breeding, he takes up the problems and the mechanisms of reproduction. Here is included an excellent chapter on endocrines by Dr. F. N. Andrews. A well-written and very complete section is devoted to the principles of heredity and their bearing on livestock production. The final section deals with the art of breeding, including systems of mating, selection and a discussion of future possibilities in the development of methods of improving farm animals. The book is well illustrated and is exceptionally well adapted to its purpose.—*L. H. Snyder.*

Breeding and Improvement of Farm Animals, by Victor A. Rice. xx+750 pp. New York, the McGraw-Hill Book Co., 1942. $5.00.

Economic Zoology

This book was written to serve either as a textbook for a course in economic zoology or as collateral reading in elementary courses in zoology. Earlier editions of Professor Reese's book have well served to acquaint students with the importance of zoology in public welfare. Both the morphology and the economic importance of each of the major groups of the animal kingdom are discussed. As in earlier editions, the morphology is subordinated to the economic aspects of each animal group.

Those familiar with the third edition will find the new book more legible, as it is printed in one size larger type. This, together with some twenty figures which have been replaced with better ones, constitute the major changes over the third edition. Some minor changes and additions have been made to bring the subject matter up to date and the bibliography has been considerably extended. However, the latest references are not always included and the discussion of some sections might have been enlarged to advantage in view of the amount of information available. The quality of workmanship and materials used in the manufacture of the book are excellent.—*W. M. Tidd.*

Outlines of Economic Zoology, by Albert M. Reese. xii + 359, 191 figs. Philadelphia, The Blakiston Company, 1942. $3.25.

THE VEGETATION OF TRUMBULL COUNTY, OHIO[1]

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In this paper an attempt is made to describe the original forest vegetation of Trumbull County, Ohio. The distribution of generalized vegetation types is indicated by a map. These types are described and an analysis of their successional relationships is based on a study of existing remnants, secondary successions and historical records of the original vegetation.

Investigations of this kind are not only of historical value, but it is also recognized that the natural vegetation of a region is an expression of the total effect of a complex of environmental factors, and its use as a practical "indicator" of environment is increasing.

THE REGIONAL BACKGROUND

Trumbull County is located in northeastern Ohio, adjacent to Pennsylvania. It lies midway between the glacial boundary and Lake Erie, and a single county lies between it and the lake. It is approximately twenty-five miles square. Its subdivisions and principal streams are shown in the accompanying map (Figure 1).

The elevation above sea level ranges from 800 to 1260 feet. Within this range altitude is of much less significance in relation to vegetation than relative local relief. Application of this concept of "relative relief," developed by Smith (1935), clearly demonstrates two distinct types of topography in the county. With the exception of a small portion in the extreme northwestern corner, the area north and west of the Defiance moraine, which extends through the towns of Southington, Champion, Bazetta, Johnston and Gustavus (Cushing, Leverett and Van Horn, 1931), is level to gently rolling, while the dissected plateau in the eastern and southeastern parts of the county varies from rolling to decidedly hilly and broken. In this region underlying rocks through their influence on topography may have an indirect influence on vegetation. The rugged topography of the eastern and southeastern portions of the county is related to the more resistant character of some of the rocks of the Pennsylvanian system.

Over much of the old valley in the western part of the county and upon the broad divides, natural drainage has not yet become well established. This is due to the location of the county upon the divide between the Great Lakes and the Ohio River, the reversal of drainage brought about by the glacier, and the comparatively short time which has elapsed since glaciation.

With the exception of small areas where the bedrock lies at or near the surface, or where muck or peat deposits have formed, the soils are of glacial origin. Over nine-tenths of the soils of Trumbull County originally were in need of internal drainage for agricultural use. Surface drainage varies to a much greater extent. In this region vegetation types correlated with soil types are also correlated with topographic features. When mapped soil types are an expression of topography and drainage they are useful indicators of vegetation.

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[1]Papers from the Department of Botany, The Ohio State University, No. 447. A more detailed account is contained in a thesis presented to the Graduate School of The Ohio State University for the Master of Science degree, 1937. The advice of Dr. H. C. Sampson and Dr. E. N. Transeau is gratefully acknowledged.

As might be expected, this region has greater climatic similarity to northwestern Pennsylvania and western New York than to central and western Ohio. Northeastern Ohio has, on the average, later spring frosts and earlier autumn frosts than the rest of the state, a slightly lower average temperature, precipitation more uniformly distributed and more of it in the form of snow, and less frequent drought periods of significant duration.

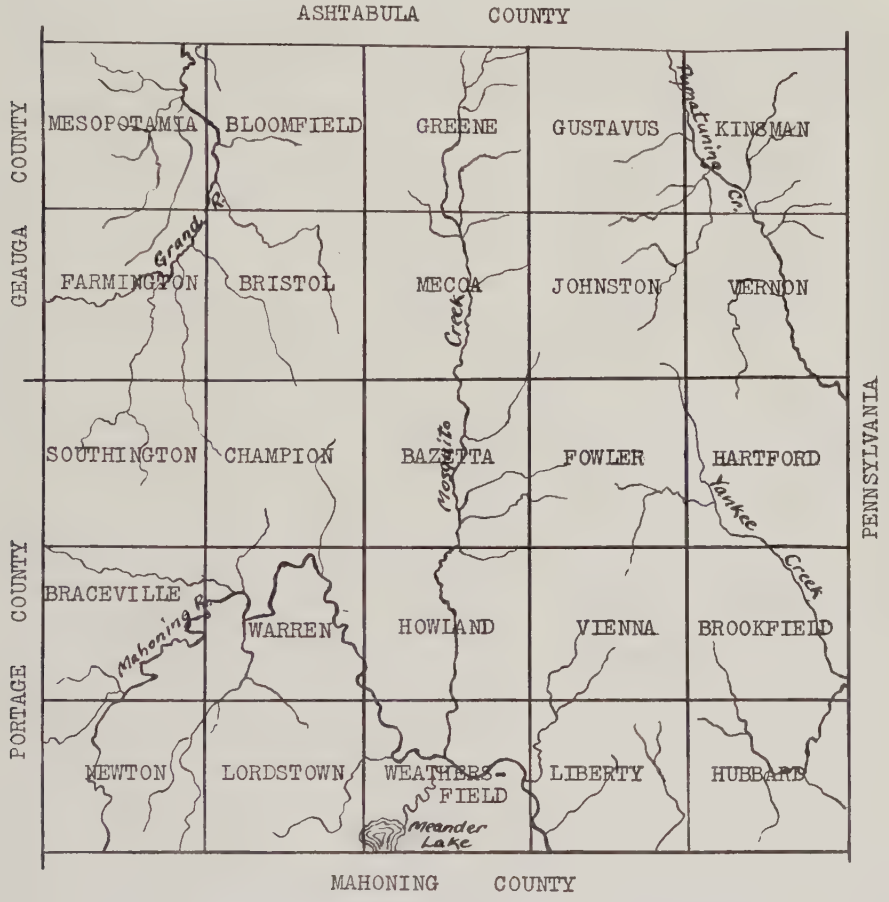

FIG. 1. The towns and principal streams of Trumbull County, Ohio.

METHODS

In an attempt to reconstruct an accurate picture of the original vegetation, the following sources of information were used: (1) historical records, including land survey notes, written descriptions by local historians, verbal accounts by old residents, timber buyers and sawmill operators, and herbarium records; and (2) field observations, including recording of present-day vegetation, analysis of least disturbed areas, observation of secondary successions on areas of known vegetational history as a basis for establishing indices to be used in further field work, and local correlation of vegetation types with topography and soils.

Trumbull County is a part of the Western Reserve included in the original land grant to Connecticut. In 1795 this area was sold to the Connecticut Land Com-

pany, which employed surveyors to divide the land into towns[2] five miles square. A part of their job was to describe the timber, the suitability of the land for agriculture and any apparent "mineral deposits" along these five mile traverses. Their descriptions provided the only basis for evaluation of the land, and considerable pains were taken with them. The traverses of present-day Trumbull County were completed in 1796 and 1797.

The nature of these survey notes is such that for our purposes they amount to transects of the vegetation at five mile intervals. They do not give a detailed picture, but the general features of the original vegetation stand out quite clearly. A thorough study leaves no doubt as to their reliability. Apparently the species were listed in approximate order of abundance. Usually a description was given for every mile, but in a few cases, where distinct changes occurred, there were as many as three descriptions to the mile. In other places the "timber" was described as "the same" for several miles. Lists of species, sometimes annotated, varied from one (e. g., *white oak*, on the south line of Newton) to several (e. g., *cherry, walnut, hardbeam, ash, beech, maple, oak, ironwood, elm, basswood, butternut, cucumber, boxwood,* in the mixed mesophytic area between Vernon and Kinsman and east of Pymatuning Creek).

In the present study field work formed the principal basis for mapping of forest types in all areas that had even a small percentage of wooded land. The various historical records were used as contributory evidence and seldom modified the final conclusions. In most cases history merely confirmed the evidence of the existing vegetation. In the urban and thickly settled suburban areas of Warren, Niles, Youngstown and Sharon, Pennsylvania, it was necessary to rely to a greater extent on historical records and generalization of types on the basis of remnants in adjacent and similar territory. The rural areas of the county practically all contain enough wooded land to enable one to reconstruct the original forest associations after he has acquired a knowledge of the secondary successions in the area. According to the United States Census of Agriculture (1935), 19 per cent of the farm land of the county is in woods. Probably the percentage of rural non-farm land in woods is higher. In using farm woods as a basis for judgment, it must be kept in mind that the sites left in woods are frequently either too wet or too rough for agriculture. Consequently these sites are often unfavorable for the development of the regional climax vegetation and these woods might be misleading without site evaluation.

VEGETATION TYPES

The following outline includes the types clearly recognizable in the original vegetation of the county. Further variants were probably extremely local in occurrence and are discussed under related types. In general, the types recognized by Sampson in northern Ohio (1927, 1930a) are followed. Associations are named for their dominants in order of abundance, the dominants named making up over half the stand. This rule is not, however, rigidly applied to transition types, which are sometimes identified by indicator species.

Arrangement of the series is roughly in order of decreasing drainage. The associations are grouped into generalized types for convenience in mapping. Local areas of historical interest showing little direct relationship to other present-day vegetation are classified separately as relict types.

Chestnut types.....Chestnut
Oak-chestnut

[2]The designation "town" is used here, as in New England, to refer to the subdivisions elsewhere called "townships." It is customary when referring to these units to use their names alone, without specifying "Town of ——" or "—— Township."

Upland oak types	Mixed oak
	Oak-hickory
	White oak
	Oak-maple
	Oak-maple-tulip
Mixed mesophytic type	
Beech-maple types	Maple-oak-beech
	Maple-beech
	Beech-maple
Transition types	Red oak
	Wet beech
	Mixed
	Swamp oaks
Swamp forest types	Elm-ash-red maple
	Pin oak
	Black ash
	Sycamore-willow
Relict types	Hemlock
	White pine
	Bogs
	Treeless areas

In presenting the accompanying generalized map (Fig. 2), certain points should be mentioned. The similarity of the secondary forests on much of the area originally occupied by the better drained transitional phases of the swamp forest, and the lack of detailed historical information for the entire area, have made it advisable to map together all areas too wet for the beech-sugar maple community. Local spots occupied by almost pure stands of beech, too poorly drained for sugar maple, thus occur within areas generalized as swamp forest.

Gradual transitions from one type to another in certain parts of the county, notably in Southington, Gustavus and Vienna, have made the boundaries arbitrary. Certain areas of rolling topography, especially in Southington and south of the Mahoning River, exhibit extreme local variation. All such problem areas are mapped as their predominant type, on the basis of available information. It is also probable that mixed mesophytic forests were much more extensive than indicated in the southeastern part of the county. However they are shown only where direct information was available.

It is intended by these criticisms to define the value and recognize the limitations of the accompanying map. It shows generalized types graphically and as accurately as possible.

Chestnut Types

Chestnut was originally a dominant in local types which did not occupy more than 3 per cent of the area of the county. The most extensive stands occurred in the eastern tier of towns and in the northwestern corner of the county. Sites occupied by chestnut were of two major types: (1) overdrained sites, usually ridges, associated with sandstone outcrops; (2) sandy second terrace soils, particularly along Mosquito Creek in the north central part of the county.

Chestnut was an important component of the mixed mesophytic forests in the eastern and northeastern towns. Areas so mapped probably included small spots on which chestnut was a dominant species. It was also locally present in the beech-maple stands in the northwestern and northeastern towns.

Characteristic tree species of the oak-chestnut association included the following:

DOMINANTS

Black oak	*Quercus velutina* Lam.
Chestnut	*Castanea dentata* (Marsh.) Borkh.
Chestnut oak (locally)	*Quercus montana* Willd.
Red oak	*Quercus borealis* Michx. var. *maxima* (Marsh.) Ashe
White oak	*Quercus alba* L.

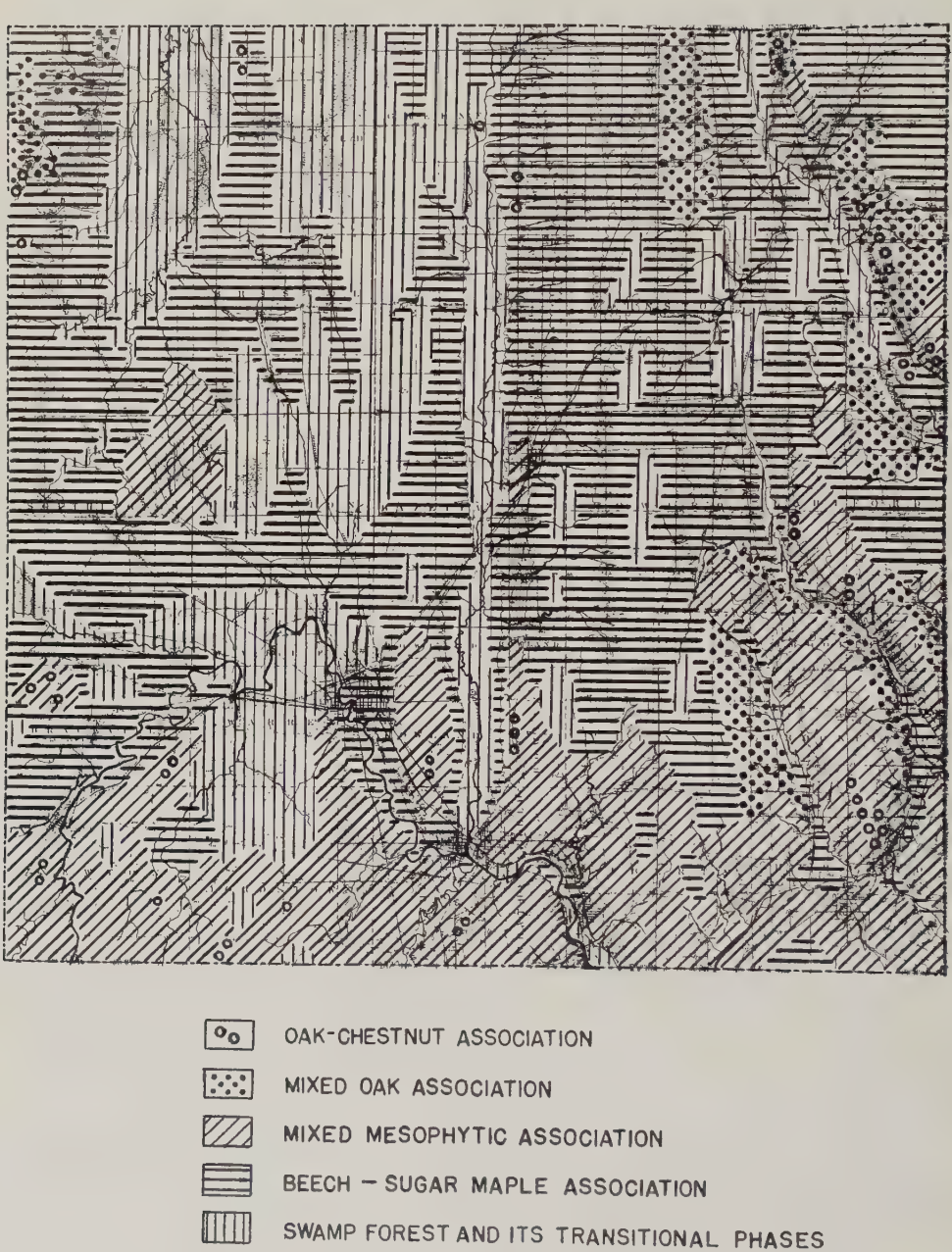

FIG. 2. Generalized map of vegetation types of Trumbull County, Ohio.

Associated Species

Sassafras	*Sassafras variifolium* (Salisb.) Ktze.
Red maple	*Acer rubrum* L.
Tulip tree	*Liriodendron Tulipifera* L.
Ironwood	*Ostrya virginiana* (Mill.) K. Koch
Flowering dogwood	*Cornus florida* L.
Juneberry	*Amelanchier canadensis* (L.) Medic.
Wild cherry	*Prunus serotina* Ehrh.
White ash	*Fraxinus americana* L.
Pignut hickory	*Carya glabra* (Mill.) Sweet

Upland Oak Types

The upland oak types originally occupied between 25 and 30 per cent of the area of the county, and were only exceeded in area by beech-maple. With the notable exception of the white oak area in midwestern Trumbull County, they were principally located on the rolling topography to the south and southeast.

Considerable local variation occurred in these types. North and east slopes were much more mesic than those facing south and west. In fact, typical mixed mesophytic stands were probably of local occurrence throughout the area. However only stands of significant size or areas where the type was predominant were so mapped. Local stands of upland oaks in areas dominated by more mesophytic associations were found on the southwest-facing slopes above Pymatuning Creek in Kinsman and Yankee Creek in Hartford.

The most extensive oak type was the mixed oak association, which corresponds with Type 49: *White Oak—Black Oak—Red Oak*, of the Committee on Forest Types, Society of American Foresters (Hawley et al, 1931).[3]

Dominants

White oak	*Quercus alba* L.
Black oak	*Quercus velutina* Lam.
Red oak	*Quercus borealis* Michx. var. *maxima* (Marsh.) Ashe

Associates

Red maple	*Acer rubrum* L.
Shagbark hickory	*Carya ovata* (Mill.) K. Koch
Sour gum	*Nyssa sylvatica* Marsh.
Wild cherry	*Prunus serotina* Ehrh.
Shingle oak	*Quercus imbricaria* Michx.
Sassafras	*Sassafras variifolium* (Salisb.) Ktze.
Pignut hickory	*Carya glabra* (Mill.) Sweet
Small-fruited hickory	*Carya ovalis* (Wang.) Sarg.
Linden	*Tilia americana* L.
Flowering dogwood	*Cornus florida* L.
Sugar maple	*Acer saccharum* Marsh.
White ash	*Fraxinus americana* L.
American elm	*Ulmus americana* L.
Slippery elm	*Ulmus fulva* Michx.
Juneberry	*Amelanchier canadensis* (L.) Medic.
Scarlet oak	*Quercus coccinea* Muench.
Chestnut	*Castanea dentata* (Marsh.) Borkh.
Butternut	*Juglans cinerea* L.
Tulip tree	*Liriodendron Tulipifera* L.

Black oak dominated the drier phase and red oak the wetter phase, while white oak was probably the most abundant species throughout the entire range of habitats covered by the association in Trumbull County. Shingle oak was restricted to the parts of the county where the oak types occurred, but it was also a component of the swamp forests within this range. Scarlet oak was restricted to the drier sites and even there was very infrequent.

[3]Types listed by this committee are subsequently referred to as S. A. F. types.

In the morainal region of Southington and parts of the towns south of the Mahoning River, local increase in the abundance of the hickories gave rise to an oak-hickory association. Land survey records indicate that this type was originally much more extensive than would be inferred from present day vegetation, particularly in the latter region.

Other local variants dominated by oaks occurred in these two regions and in the morainal area in Gustavus. The oak-maple association occurred locally in all three regions. Dominants were white oak, red oak and sugar maple. Sugar maple was sufficiently abundant for sugar making in these areas, but was exceeded in abundance by the oaks.

The oak-maple-tulip association is also known to have occurred locally, especially in Lordstown and Gustavus, and with the last mentioned association occupied the most mesic habitats dominated by oaks. In fact, the oak-maple-tulip association approached and graded into the mixed mesophytic association, being distinguished from it by the more pronounced dominance of the species named.

The white oak stands already mentioned occurred on the area of Mahoning silt loam (Conrey and Burrage, 1937) in Southington and adjoining towns. Here white oak was decidedly predominant, forming almost pure stands in many places. The type boundary was well defined on the east, but to the west there was a more gradual transition, grading through oak-maple and oak-maple-beech to beech-maple. The soil type has fair to good surface drainage, but a heavy subsoil makes internal drainage very poor, and the soil tends to bake and crack badly in dry weather.

Mixed Mesophytic Forests

In analyzing "the mixed mesophytic forest community in northeastern Ohio," Sampson (1930b) pointed out that it is a special type of transitional community occupying a position between dry sites covered by oak-chestnut and moist sites in which the complex of factors is favorable to the dominance of beech-maple, and is characterized by an increase in abundance of secondary species intermingled with the dominants of two or more associations.

The evidence obtained indicates that not less than 10 per cent of the area of the county was originally covered with forests of this type, principally in the eastern fourth and on the east-facing slopes of the extreme northwestern corner of the county. In Trumbull County this type is almost entirely restricted to slope habitats, as the internal drainage of the soil is seldom sufficient elsewhere. Slopes that are so steep that they are excessively drained, or so exposed that evaporation is excessive, are characterized by more xeric types, and the mixed mesophytic community is chiefly restricted to more protected situations such as "coves" or ravines, north and east-facing slopes and the more gradual west slopes. Both a good supply of water and good internal drainage (soil aeration) seem to be required.

As previously stated, the mixed mesophytic community occupies a position between oak and chestnut types on the one hand and beech-maple on the other. Although the dominant species of these associations occur in the mixed mesophytic community, other secondary species equal or exceed them in degree of dominance. Species typically showing increased abundance in this community are:

Cucumber tree	*Magnolia acuminata* L.
Tulip tree	*Liriodendron Tulipifera* L.
Red maple	*Acer rubrum* L.
White ash	*Fraxinus americana* L.
Sour gum	*Nyssa sylvatica* Marsh.
Linden	*Tilia americana* L.
Butternut	*Juglans cinerea* L.
Wild cherry	*Prunus serotina* Ehrh.
Slippery elm	*Ulmus fulva* Michx.
American elm	*Ulmus americana* L.

Other species characteristically present, but showing decidedly less dominance than in adjacent associations, are:

Chestnut	*Castanea dentata* (Marsh.) Borkh.
Red oak	*Quercus borealis* Michx. var. *maxima* (Marsh.) Ashe
Sugar maple	*Acer saccharum* Marsh.
White oak	*Quercus alba* L.
Black oak	*Quercus velutina* Lam.
Beech	*Fagus grandifolia* Ehrh.

As Sampson (1930b) pointed out, the invasion order of some of the species varies with the nature of the substratum, and local variation in the relative abundance of certain individual species commonly occurs. It is obvious that a great number of local variants may occur. This extreme local variation has given rise to the general name applied to the community since any binomial or trinomial term would only be locally applicable.

Occurring in parts of the county were certain rather local associations and variants which approached the mixed mesophytic in composition and ecological status. This is true of the oak-maple-tulip association previously mentioned as occurring in Gustavus and Lordstown. Both white and red oaks occurred in this association. Sugar maple was more abundant than red maple. Cucumber was absent or rare in both localities. Hickory was an important constituent in Lordstown. Both a drier phase—oak-chestnut-tulip—, and a wetter phase—maple-oak-beech—are known to have occurred locally in the morainal region of Gustavus. With the exceptions noted, these local variants differed very little in composition but are distinguished by differences in dominance.

The mixed mesophytic areas indicated in Mesopotamia contained a high proportion of red oak, tulip, chestnut and sugar maple. Cucumber was absent and white oak infrequent. These areas were closely associated with a maple-oak-beech association similar to that mentioned in Gustavus.

The transitional types in parts of Southington were of somewhat different composition. Rather than being mixed mesophytic in character they seemed to consist largely of the dominants of the adjoining oak and beech-maple types. They might properly be designated as oak-maple-hickory or oak-maple-beech. The large white oaks characteristically overtopped these forests and were more dominant from size than abundance. The hickories and walnuts showed local increases in abundance in these transition types but chestnut, tulip, cucumber and sour gum were either rare or absent.

Beech-Maple Types

A greater part of the area of Trumbull County was originally covered by beech-sugar maple forests than by any other type. Although extensive stands were largely restricted to the northern two-thirds of the county, they are believed to have occupied between 40 and 45 per cent of the total area.

This part of the county varies from undulating to gently rolling, with little stream dissection. Beech-maple typically and almost exclusively occupied slopes of from 40 to 100 feet per mile in this area. More poorly drained areas were occupied by various phases of the swamp forest formation and areas of greater gradient graded into mixed mesophytic and more xeric types.

In the more deeply dissected areas to the south and southeast, beech-maple types were restricted to certain local situations. Stands occurred on some rather level and undissected upland sites between streams in Hubbard, Liberty and Vienna. Occurrence of beech-maple types in stream valleys was probably more common, especially on second terraces. Local stands on such sites were apparently common in the southern third of the county, the most extensive being along the Mahoning River, Duck Creek and Little Yankee Creek. Local variation in the

direction of a pure sugar maple type was common on these terraces along the Mahoning River and its branches in the southwestern part of the county.

Most of the beech-maple forests of this area conformed to the generalized type listed as S. A. F. Type 57: *Beech-Sugar Maple* (Hawley et al, 1931) and described by Gordon (1932).

Dominants	
Beech	*Fagus grandifolia* Ehrh.
Sugar maple	*Acer saccharum* Marsh.
Commonly Associated Species	
Red oak	*Quercus borealis* Michx. var. *maxima* (Marsh.) Ashe
White ash	*Fraxinus americana* L.
White oak	*Quercus alba* L.
Red maple	*Acer rubrum* L.
Wild cherry	*Prunus serotina* Ehrh.
Bitternut hickory	*Carya cordiformis* (Wang.) K. Koch
Shagbark hickory	*Carya ovata* (Mill.) K. Koch
Linden	*Tilia americana* L.
Tulip tree	*Liriodendron Tulipifera* L.
American elm	*Ulmus americana* L.
Slippery elm	*Ulmus fulva* Michx.
Ironwood	*Ostrya virginiana* (Mill.) K. Koch
Blue beech	*Carpinus caroliniana* Walt.

Variants occurring in Trumbull County were due to shifts in relative dominance with little change in species present. Over most of the area beech and maple were decidedly predominant, in some cases making up over 90 per cent of the total stand. The dense shade in these forests was an important factor in suppressing other species. On most of the sites beech exceeded maple in abundance, this dominance becoming greater on wetter soils. On some upland flats a "wet beech" type occurred in which beech was predominant and was associated with swamp forest species, with sugar maple entirely absent. Such areas are discussed and mapped as transitional types.

A maple-beech sub-type occurred in Mesopotamia and Gustavus on east slopes considerably steeper than those occupied by typical beech-maple, and was associated with a further variant which might be termed maple-oak-beech, in which red oak exceeds beech in abundance. These variants approach the mixed mesophytic community which is present in both these areas.

Swamp Forests

Prominent among the original forest types of Trumbull County were a number of associations belonging to the northern swamp forest formation. These forests probably occupied 20 to 25 per cent of the total county area, being only exceeded in area by the beech-maple and oak types. As pointed out by Sampson (1930a), these forests were perhaps unexcelled anywhere in the northern and central portions of the North American deciduous forest in the number of tree species represented. Variations in the relative requirements of these species and in the vegetational history of the areas on which they occur gave rise to a large number of more or less distinct phases within the region considered.

Swamp forests dominated those areas in the county characterized by level to gently undulating topography, heavy, highly acid soils and a very high water table during at least the greater part of the growing season. Both surface and internal drainage are very poor in this range of habitats. These habitats include (1) flood plains, and (2) pre-erosion post-glacial flats.

The alluvial or "first bottom" soils of the flood plains, subject to more or less frequent flooding, were almost entirely covered with swamp forests. The better drained second terrace soils had largely gone over to beech-maple types, but the extensive, flat, poorly drained terraces of the Grand River in Farmington and

Mesopotamia were still too wet for sugar maple. It is not unusual for an area of this valley floor two or three miles wide to be inundated following a heavy rain.

Upland areas bearing swamp forests in Trumbull County are practically uneroded—drainage is very poorly developed. The most extensive areas of this type lie in the broad pre-glacial valley occupying much of the western half of the county. The glacial deposits filling this valley are from 100 to 200 feet thick in many places. Run-off from the higher ground both to the east and the west does not pass through the area but is intercepted by Mosquito Creek on the east and the Grand River on the west. Although both these streams have fairly well developed branch streams toward their opposite sides, very few branches of significant size enter the broad flat between them. This situation is apparently due to a combination of several factors, including the comparatively short time since glaciation, the very level topography, and the impervious character of the glacial soils. Much smaller areas of similar character occur throughout the county on the upland flats between streams.

In his paper on succession in the swamp forest formation of northern Ohio, Sampson (1930a) recognizes the elm-ash-soft maple community as basic for the entire area, at the same time recognizing (1) "certain successional or transitional phases of the swamp forest that frequently developed previous to the invasion of beech, hard maple or white oak," and (2) "certain swamp forest communities in which some of the characteristic secondary species of the elm-ash-soft maple community became sufficiently abundant to be classed among the principal dominants." Elm, ash and soft maple frequently remained dominant in the transitional phases referred to, but degrees of improvement in drainage and soil aeration were attended by the entrance of certain characteristic species. Transition types in the following successional phases of the elm-ash-soft maple community listed by Sampson are recognized from, and named for such indicator species. They may be dominants but are not necessarily so.

(1) Elm-Black Ash-Soft Maple Association.
(2) Bur Oak-Big Shellbark Hickory Transition.
(3) Red Oak-Linden Transition.
(4) Tulip-Walnut Transition.

In the swamp forests of Trumbull County variants and successional phases in which the indicator species attained the rank of dominants were apparently more extensive than the elm-ash-soft maple community. Its best development was attained adjoining the willow-sycamore stream margin association on the flood plains of the larger streams, on lighter and less acid soils than those of the upland swamps. Silver maple (*Acer saccharinum* L.) was practically restricted to such habitats and, even there, was usually less abundant than red maple (*Acer rubrum* L.). Black ash (*Fraxinus nigra* L.) was frequently predominant in the wetter places, while white ash, occurring on the better drained portions, was often exceeded in abundance by the maples.

The upland swamp most nearly like the elm-ash-soft maple of flood plains correspond more closely in order of abundance with S. A. F. Type 26: *Black Ash—American Elm—Red Maple* (Hawley et al, 1931). This type occurred on soils wet the year round, highly acid and frequently mucky. Black ash was much more abundant on these upland areas than on flood plains, in places forming extensive pure stands, notably in Bloomfield and Champion. Silver maple was practically absent, while red maple was often more abundant than elm. Locally yellow birch was an important constituent.

Alder (*Alnus*), willow (*Salix*), and buttonbush (*Cephalanthus*) occurred locally on marshy areas associated with this type. Such marshes commonly occupied from a fraction of an acre to several acres. The willow swamps above beaver ponds in Champion, Johnston, Bloomfield and Southington were the most extensive areas of this sort of which we have record.

Entrance of bur oak (*Quercus macrocarpa* Michx.) and big shellbark hickory (*Carya laciniosa* (Michx. f.) Loud.) into the swamp forest indicates some improvement in drainage and soil aeration. Areas in which these species became common to abundant are known to have existed along the Grand River in Mesopotamia and Bloomfield, along Little Yankee Creek in Hubbard, and locally in Newton and Lordstown. The total area occupied by such forests was, however, quite small. This transitional phase was more commonly developed as a swamp oak type, with marked increase in abundance of pin oak (*Quercus palustris* Muench.) and swamp white oak (*Quercus bicolor* Willd.), and very little hickory present. Such a type characterized a large part of the Grand River flats and some of the heavy clay upland soils. American elm, red maple and sour gum were the most frequent and most abundant associates of the swamp oaks.

Stands of almost pure pin oak occurred as a local variant, representing the wettest phase of the swamp oak type. Such areas are known to have occurred in the original forests of Champion and Lordstown, and along Mosquito Creek in Howland, and pin oak has become more widespread and quite abundant in the secondary forests.

With slight improvement in drainage and aeration shagbark hickory and red oak enter both the big shellbark-bur oak transition and the swamp oak association, frequently in considerable abundance. Shagbark hickory is more abundant in these transitional phases of the swamp forest formation than in any other association occurring in Trumbull County. White ash seems to have attained its maximum abundance in this phase of the swamp forest, particularly in the southwest quarter of the county. Much of the swamp forest of the eastern half of the county has reached this stage in succession with red oak frequently sharing the rank of dominant with elm, white ash, and red maple, and such secondary species as shagbark hickory, bitternut hickory, sour gum and slippery elm attaining local prominence. While these successional phases correspond with Sampson's red oak-linden transition, it is of interest that linden is only very locally abundant in Trumbull County.

A fourth phase of the swamp forest, termed the tulip-walnut transition, is recognized in those situations in which these species along with butternut and cucumber tree also enter before invasion and dominance of beech, sugar maple or white oak. Perhaps the most typical development of this phase occurred locally on the terraces of the Mahoning River, Mosquito and Pymatuning Creeks, but the large pre-erosion flat in north central Trumbull County contains portions which have reached a corresponding phase of development. In general aspect much of this area was a mixed swamp forest, consisting of an intimate mosaic of intergrading transitional phases. The topography varies from level to gently undulating, and the slopes average only a few feet to the mile, but local variation in drainage was enough to bring about the development of a mosaic forest, with the previously described transitional phases locally represented. Within this area some "ridges" only a few feet higher than the surrounding territory were covered with white oak or beech, but by far the greater part of the area was dominated by swamp forest species. Sugar maple was very infrequent.

Some portions of this upland flat had developed the wet beech type. The wet beech flats differed from the beech-maple association in several respects. They were practically restricted to the upland flats west of Mosquito Creek, on heavy clay soils with the water table at or near the surface of the ground most of the growing season. Sugar maple was almost entirely absent, but beech made up as much as 80 per cent of the stand in many cases. The commonest associates were swamp forest species, such as red maple, shagbark hickory, elm, sour gum, red oak and pin oak, with cucumber tree locally frequent to common. On such areas beech invaded the swamp forests far in advance of sugar maple. Cucumber invaded these areas before tulip.

The root systems in such forests are very superficial and the existing remnants have suffered greatly from pasturing and recent droughts. In this swampy region, the beeches frequently have dead tops. These forests would fall into S. A. F. Type 58: *Beech. Pin Oak* is given as a variant of this type, but in this region pin oak is an index of a wetter site that is invaded by beech as the drainage improves.

A similar forest community was described by Hicks (1933) for Ashtabula County, the most extensive area occurring in the south central portion of that county, just north of the headwaters of Mosquito Creek. Sampson (1930a) mentions that "wet beech forests with elm, hickory and red maple as the principal secondary trees are sometimes found in Portage County." A similar community is described by Braun (1916) as the pre-erosion climax of the hydrarch succession in the Cincinnati region. Although the soils of that region differ in their origin from those of northeastern Ohio, those on the areas in question are alike in their heavy character, poor drainage and high acidity.

RELICT TYPES

Certain associations occurring very locally in Trumbull County have little direct relationship to present day vegetation and are best explained as remnants of types which occupied the region much more generally in past stages of its vegetational history. Such local areas are not only interesting because of their unique nature, but because of their indication of vegetational history.

Hemlock

Although extensive hemlock forests occurred on upland flats in Ashtabula County within ten miles of the north edge of Trumbull County (Hicks, 1933), this species was here restricted to gorges and protected stream banks. With the exception of two gorges in the extreme northwestern corner, it was found only on scattered sites in the eastern half of the county.

Only in the Mesopotamia gorges did the hemlock become abundant enough or occupy sufficient area to form well-defined forest types. The least exposed situations, particularly steep north-facing slopes, were covered with pure hemlock. More extensive was a hemlock-birch-beech association which graded through a beech-maple-hemlock transition into the beech-maple of the surrounding upland. This transitional stage was sometimes characterized by an abundance of red oak and the presence of chestnut, and then approached a local mixed mesophytic type.

The flora of the gorges was characterized by the following species not found on the surrounding upland:

Hemlock	*Tsuga canadensis* (L.) Carr.
Yellow birch	*Betula lutea* Michx. f.
Sweet birch	*Betula lenta* L.
Mountain maple	*Acer spicatum* Lam.
Red-berried elder	*Sambucus pubens* Michx.
American fly honeysuckle	*Lonicera canadensis* Marsh.
Bush honeysuckle	*Diervilla Lonicera* Mill.

White Pine

Insofar as known, only one area of white pine (*Pinus Strobus* L.) occurred in the primeval forest of Trumbull County. This stand originally occupied about 100 acres in the south central part of Kinsman, east of Pymatuning Creek. This area consisted of low gravel ridges with small bogs lying between them, the pines occupying both the bogs and the higher ground. According to reports of local residents, trees over four feet in diameter were present in the original stand. White oak and sugar maple were the most frequent associates of the pine on the low ridges, while the boggy portions characteristically included alder, yellow birch, winterberry (*Ilex verticillata* (L.) Gray) and high bush blueberry (*Vaccinium corymbosum* L.).

Bogs

The poorly drained upland flats of Trumbull County have been sites favorable to the maintenance of bog vegetation until recent times. Even today such characteristic bog species as sphagnum and high bush blueberry occur frequently in the wetter phases of the swamp forest.

Two bog areas dominated by tamarack (*Larix laricina* (Du Roi) Koch) are known to have been present in Trumbull County at the time of settlement. The larger of these was the famous "Bloomfield swamp" occupying the eastern third of Bloomfield. About one and one-half square miles of this area was covered with tamarack. It occurred in a pure stand, but was entirely surrounded by a zone of black ash, which graded outward into the mixed swamp forest characteristic of this flat upland.

Most of the tamarack was destroyed by fire in 1854, and periodic fires since then have altered the vegetation and destroyed the surface muck of a large part of the area. The swamp was drained about 20 years ago and a large part has been cleared and is being used for market gardening. A few tamaracks, the largest about 15 inches in diameter, remain on the area. The bulk of the accompanying vegetation consists of the following species:

Pin oak	*Quercus palustris* Muench.
Red maple	*Acer rubrum* L.
American elm	*Ulmus americana* L.
Yellow birch	*Betula lutea* Michx. f.
Quaking aspen	*Populus tremuloides* Michx.
Poison sumac	*Rhus vernix* L.
High bush blueberry	*Vaccinium corymbosum* L.
Toothed arrow wood	*Viburnum dentatum* L.
Winterberry	*Ilex verticillata* (L.) Gray
Alder	*Alnus incana* (L.) Muench.
Smooth sumac	*Rhus glabra* L.
Blackberry	*Rubus allegheniensis* Porter
Swamp dewberry	*Rubus hispidus* L.
Chokeberry	*Aronia melanocarpa* (Michx.) Ell.
Hardhack	*Spiraea tomentosa* L.
Meadowsweet	*Spiraea alba* Du Roi
Clematis	*Clematis virginiana* L.
Goldenrods	*Solidago* spp.
Asters	*Aster* spp.

A much smaller area of tamarack was encountered on the west edge of Braceville by the surveyors who ran the Trumbull-Portage county line. These trees were likewise destroyed by fire some time previous to 1900, and the area is at present covered with a pin oak swamp.

Evidence of bog shrub and bog meadow associations is not likely to be as well preserved. Destruction by fire, drainage and cultivation is almost complete. The following list of bog locations is based chiefly on historical evidence of the occurrence of cranberries.

(1) The portion of the Bloomfield bog south of the center road contained about 50 acres of sphagnum-cranberry bog meadow, surrounded by a zone of blueberries.

(2) A cranberry bog in the southeastern corner of Johnston is locally reported to have covered about 200 acres, and lay above a beaver dam.

(3) A bog in the northeastern quarter of Lordstown was mentioned in a local history. The area has been drained and the only remnant is a sedge meadow of 3 or 4 acres.

(4) A bog of about 30 acres was located in the northwest corner of Newton. The cranberries were eliminated by drainage during railroad construction.

Treeless Areas

Few areas in Trumbull County were naturally treeless. Since such areas were unusual and since they indicated the character and value of the land, they were recorded in the survey notes.

Sears (1926) has interpreted three of these areas as "prairies" in his map of the prairies of Ohio. The applicability of the term is very doubtful. The survey notes indicate that they were of two types: (1) "beaver meadows" and (2) "intervales."

Beaver dams gave rise to treeless areas by raising the water table and "drowning out" the trees. The ponded areas became sedge and *Calamagrostis* meadows or bogs. The Johnston cranberry bog and the treeless areas recorded in the west central part of the county were of this type. Beavers may also have been a factor in extending the area of the Bloomfield bog.

The term "intervales" seems to have been used to refer to sedge and grass meadows along streams. They seem to have occupied those portions of the flood plain where the water table was very high much of the time and soil aeration was consequently insufficient for trees. They were for the most part dominated by species of *Carex*, *Juncus*, *Glyceria*, and *Calamagrostis*.

SUCCESSFUL RELATIONSHIPS

With the development of modern plant ecology has come general recognition of the dynamic nature of vegetation. Vegetation in a changing environment is undergoing constant change. The most general vegetational changes result from shifts in climate, but local microclimatic situations and local edaphic factors, particularly soil texture and water relations, may offset or modify the effect of even a general change in climate. The result is a segregation of vegetation types—the development of a vegetation pattern.

Subsequent general changes in environment are likely to affect these local phases of the vegetation in different degree, and produce an even more complex picture. Any explanation of the relationships of the present vegetation types must therefore take into account the vegetational history of the region.

The post-Pleistocene vegetational history of this general area has been inferred on floristic grounds by Transeau (1903) and Gleason (1923) and on the basis of studies of fossil pollen by a number of workers, including Sears, who has summarized and interpreted these investigations (1932, 1935, 1938). Details of interpretation differ, but there is general agreement on the broad outline presented in the following paragraphs.

At the time of maximum glaciation a zonation of vegetation similar to our present continental zonation is believed to have existed south of the ice border. The narrow tundra zone nearest the ice margin was bordered by a northern coniferous forest, the most extensive southern development of which occurred at high altitudes. Between this boreal forest and the deciduous forest farther south occurred the northern types of mixed forests of conifers and hardwoods.

In our region the receding glacier was probably closely followed by tundra vegetation, followed in turn by spruce and fir on the better sites. With the development and extension of forest vegetation over most of the area during this and subsequent stages, the tundra vegetation became more and more restricted to shallow depressions and flat pond and stream margins too wet for trees. Edaphic conditions on some of these sites retarded succession to such a degree that these boreal bogs with their accompanying bog forest of tamarack persisted until destroyed by human agencies.

The boreal forests of spruce and fir seem to have been succeeded by mixed forests such as we now find in the St. Lawrence valley. Sears interprets the great abundance of pine at this point in the pollen profiles as indicative of change from

a humid to a dry climate. In central Ohio oak also comes in at this point. Following this pine-oak level a beech maximum occurs in Ohio and a hemlock maximum in southeastern Canada, indicating the recurrence of more humid conditions.

Such climatic shifts would result in a segregation of the various species on those sites most favorable for them, or on poorer sites more favorable for them than for other species.

The late post-glacial xerothermic period postulated by Gleason (1923) and supported by Sears' interpretation of the pollen profiles would help to account for the absence of northern conifers from the usual upland forests of the region today.

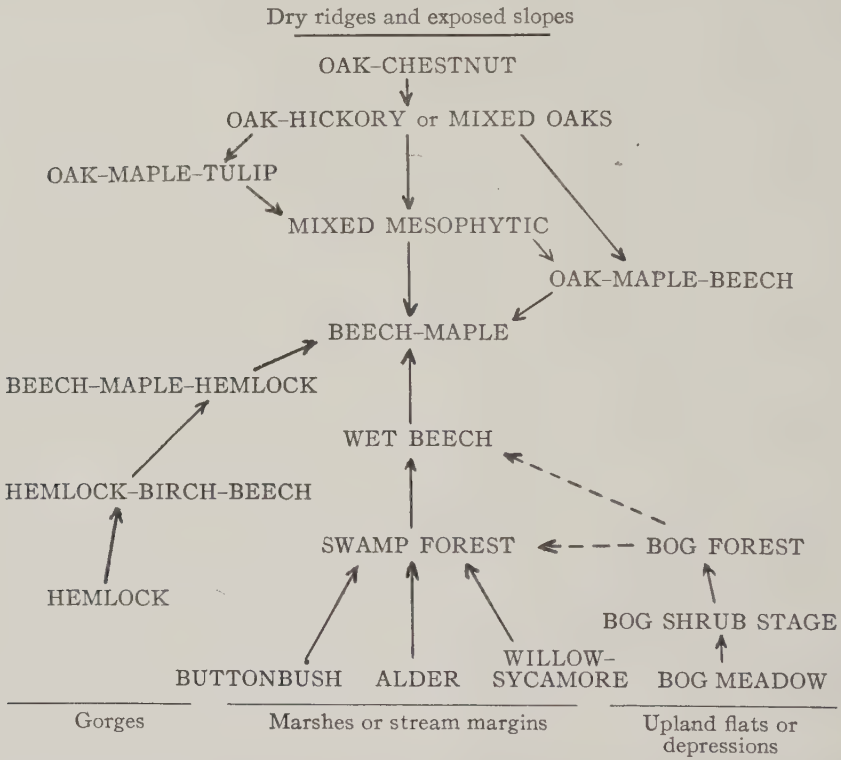

FIG. 3. Diagram showing inferred successional trends with improvement in soil moisture relations. The beech-maple climax occupies those sites on which a good soil moisture supply is combined with favorable soil aeration.

During such a climactic extreme the segregating effect of local environments would be quite pronounced. It seems logical that the more mesic forests of beech, maple and associated species already segregated out would be reduced in area, while more xeric species such as the oaks would show a marked increase both in abundance and in area dominated. Such a period would favor the development of oak forests like those in southeastern Trumbull County, although it is also possible that these slopes were covered with oaks at a much earlier time, such as the "cool, dry, pine-oak" period designated by Sears for central Ohio.

In addition to these historical successions, succession continues to occur as a result of modifications in drainage, topography and soils. The direction of change in any locality depends upon the nature of the changes in the habitat, and may be toward a more mesic or a more xeric type of vegetation. However the tendency

of these lines of succession to converge toward the regional climax association has been frequently observed, and may best be illustrated for this region by a chart (Fig. 3), which summarizes the present-day changes in the vegetation of this area which occur as soil moisture relations improve. The arrows indicate the direction of succession. The beech-maple climax occupies those sites on which a good soil moisture supply is combined with favorable soil aeration. It develops on areas with swamp and bog history as soon as drainage and consequent soil aeration improve enough to permit the entrance of its dominant species, and on areas formerly occupied by upland oak forests and related types as soon as the soil moisture supply becomes constant enough to permit their establishment. The climax status of the beech-maple association is largely due to the dense shade it produces and the shade-tolerance of its dominant species.

In the past century and a half white man has introduced a number of factors which have profoundly modified the natural vegetation. These factors include selective cutting, complete lumbering and clearing, and the pasturing, fire and artificial drainage incidental to agriculture. Successional trends in the secondary forests following such disturbance vary with the degree of modification of the habitat, but the usual effect of disturbance is a decrease in available moisture and consequently the oaks and hickories have generally increased in abundance in the secondary forests of the region.

SUMMARY

The major types of natural vegetation which covered this portion of the glaciated plateau region of northeastern Ohio may be summarized as follows:

1. The climax beech-maple association was the most extensive vegetation type occurring in the county, occupying almost half of the total area and attaining its best development on the undulating to gently rolling topography of the northern two-thirds and western parts of the county.

2. The most characteristic association of eastern and southeastern Trumbull County was a mixed oak type, which covered the steeper and more exposed slopes. Upland oak types originally occupied about one-fourth of the total county area.

3. The mixed mesophytic forest community, made up of a wide variety of species and occupying slopes having well aerated soil and continuous water supply, occupied at least one-tenth of the total county area, occurring locally in the eastern quarter and the extreme northwestern corner.

4. Forests in which chestnut was a dominant species covered only a small part of the area of the county, and were restricted to overdrained situations, characterized by thin soils over sandstone or gravel.

5. Swamp forests were most extensive in the western half of the county, particularly on the flats in the broad pre-glacial valley to the north. These forests included a number of local variants and transitional phases of the elm-ash-soft maple community which are associated with varying degrees of drainage and soil aeration.

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DATES OF RECEIPT OF THE OHIO JOURNAL OF SCIENCE IN THE OHIO STATE UNIVERSITY LIBRARY

ETHEL MELSHEIMER MILLER
Botany and Zoology Library
The Ohio State University

The practice of publishing the actual mailing dates in the issues of scientific journals is almost universally followed and is quite important for the settlement of questions of priority. The present Editor of the JOURNAL plans to conform to this custom in future volumes.

In order to establish the approximate dates of publication of the preceding volumes it was thought desirable to publish the dates on which the individual numbers had been received in the Ohio State University library for they should follow the dates of mailing very closely. However an examination of the volumes of the Ohio Journal of Science and of its predecessor, the Ohio Naturalist, showed that the various Editors had carried out this policy with only a few exceptions for volumes four to twenty-nine inclusive, November 1903 to September 1929. The records in our own library and in several other libraries in Ohio for the first three volumes of the Ohio Naturalist, November 1900 to June 1903, are too incomplete to be of much value. There is also little likelihood that they will be needed at this late date. It is thus necessary to record the dates for only volumes thirty to forty-two inclusive, January 1930 to December 1942. They are as follows:

	No. 1 January	No. 2 March	No. 3 May	No. 4 July	No. 5 September	No. 6 November
Vol. 30, 1930.	February 24	April 23	July 2	August 21	November 1	December 15
Vol. 31, 1931.	February 18	April 4	June 12	September 2	October 27	December 15
Vol. 32, 1932.	January 19	April 11	June 18	August 18	October 18	December 2
Vol. 33, 1933.	February 2	March 30	June 14	August 15	October 25	December 21
Vol. 34, 1934.	February 28	March 23	June 21	August 15	October 29	December 22
Vol. 35, 1935.	February 20	April 12	June 17	August 21	November 5	Jan. 24, 1936
Vol. 36, 1936.	March 12	May 14	July 7	September 3	November 16	December 15
Vol. 37, 1937.	February 15	March 23	June 14	August 24	October 21	December 30
Vol. 38, 1938.	February 18	March 29	June 13	August 11	October 3	December 10
Vol. 39, 1939.	February 20	March 28	June 10	July 27	October 19	December 1
Vol. 40, 1940.	January 30	April 4	June 10	August 26	October 12	December 20
Vol. 41, 1941.	January 28	February 28	June 25	August 25	October 29	December 4
Vol. 42, 1942.	February 4	March 31	May 29	August 20	October 19	December 28

FISH POPULATION OF BUCKEYE LAKE AS DETERMINED BY TRAP NETS

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Reconnaissance surveys of fish populations in the public fishing waters of Ohio were begun in 1937 as a part of the newly inaugurated fish management program. These surveys were made by trap nets of the type commonly known as "fyke" nets. The work plan and itinerary were outlined by Dr. T. H. Langlois, Chief of the Section of Fish Management. Operations of nets were under the direct control of Mr. George Messerly, with a crew of experienced net men. The fish management agent of the region worked, was charged with the technical problems of the survey including the identification of fish and the location of the nets.

Most of this extensive work was done through the summer season. Since the movement of the fish was thought to be seasonal it was deemed wise to make a more intensive survey of one body of water including all seasons.

Buckeye Lake has been the subject of numerous aquatic surveys for a number of years and many records concerning its physical, chemical and biological history are available. In 1930, during a general biological survey of this Lake under the direction of Mr. E. L. Wickliff, fyke nets were operated for two weeks out of each month through July, August and September. In June, 1938, fyke nets were operated as a part of a general survey. For these and other reasons Buckeye Lake was chosen as the "test water" for the year around population study.

DESCRIPTION OF THE LAKE

Descriptions of Buckeye Lake have appeared in various reports and are possibly best summarized by Tressler, Tiffiany and Spencer (1940). The following corrections and additions may be made to their descriptions.

Figures derived from 1938 A.A.A. aerial maps and checked against U. S. geological survey topographic maps and personal observations indicate that Buckeye Lake had at that time a water area of approximately 3,800 acres. The Lake contained four islands of from five to forty acres each and a half dozen smaller ones, all of which together totaled 141 acres. The total shoreline measured 31.5 miles, of which 22.7 miles were of the mainland.

Between 1930 (Tressler et al.) and 1939 (during the current survey) two changes apparently occurred in the Lake. One of these was a silting in of the "deep portion" near Avondale, across from Honey Creek—a principal tributary. In 1930 the depth measured seven meters, in 1939 no depth over five meters could be found. The other change was an expansion of the aquatic meadows of the bays and eastern end.

Apparently much of the expansion occurred during the summer of 1934 (Roach and Wickliff, 1934), at which time low water combined with high temperatures was conducive to good plant growth. In 1939 the area of swamp and heavy vegetation exceeded 500 acres and made up nearly one-eighth of the Lake area. Most of the submerged vegetation was hornwork (*Ceratophyllum demersum*) and was seldom found in depths exceeding six feet.

EQUIPMENT AND PROCEDURE

The standard fyke net used consisted of a lead 100 yards long and eight feet deep, hearts (wings folded in) with a spread of forty feet, as set, and a depth of eight feet, a big tunnel (breast) tapering from eight feet, at the hearts and lead

to four feet at the body and a body four feet square and twelve feet long of two cars. The mesh of the lead was two inches square, of the hearts and breast one and one-half inches square and of the body and throats one inch square. The throat leading to the first car was twelve inches square and the one leading to the last car was eight inches square. The nets were tarred.

In all but two cases the nets were set in water eight to ten feet deep with their leads tied to shore and their body stretched at right angles to the shore. In January and February, however, in order to insure against freezing the floats in the ice cover, the lead ran from the "deep spot" at Avondale back to the body which was toward shore. The net during these months, was set in from ten to twelve feet of water.

Two nets were operated continuously from June 1 to October 5, 1939. One was set off the southwest point of Journal Island in the open water of the west end of the Lake. The other was set within the vegetation beds of the east end of the Lake between Edgewater Beach and Donaldsons Landing.

Beginning in November, 1939, one net only was operated and that for but one week in each month. This net was set off a point just east of the Avondale Beach where preliminary information led us to believe there was an intermingling of both "east end" and "west end" species. Treacherous ice conditions through most of March, 1940, made operations impossible until the very end of the month, so the results are included with those for April, 1940. The operations in January and February, 1940, were carried on through an ice cover of from eight to fifteen inches.

Through August and September, 1939, a roving net supplemented the two stationary nets. This net was set for a week at a time at the following points: North shore of Journal Island, Fillbricks Point, Big Spring Bay, Liebs Island, Island No. 3, Blue Goose Point, and Avondale. These sets were made to check the catches in a variety of habitats against the stationary net catches and to check against catches of the preliminary surveys of 1930 and 1938.

The east end net was lifted daily at 8 A. M., the west end net at 1 P. M. and the roving net was usually lifted in the middle of the afternoon. The Avondale net (winter and spring sets) was lifted at 8 A. M. daily.

The last car of the net was lifted and "hung" on the side of the boat with the throat above water level to prevent the escape of the fish and at the same time to allow sufficient water to cover the bottom of the car permitting free movement of the fish.

Each fish was removed from the car by dip net, identified, measured, and marked. Scales were taken and weights were obtained from a suitable sample of all the fish. Each fish was measured to the nearest quarter of an inch. When first caught each fish was fin clipped (the right pelvic on those caught in the west end and the left pelvic on those caught in the east end, including Avondale). When caught the second time the fish were strap tagged on the gill plate. On third, and subsequent recatches, record of the tag number was made.

ABUNDANCE AND DISTRIBUTION OF FISH

In some cases, particularly in smaller bodies of water, it is possible to estimate the total number of fish present by applying mathematical formulae employing the ratio of the number of fish caught to the rate of recatching. Although our recaught fish ranged from 0.9 to 7.8 percent of the total catch in various months, we do not attempt to make an estimate of the total population in Buckeye Lake at this time since our nets obviously fished such a small portion of the Lake and sampled such a small portion of the available habitats.

Figure 1 shows the number of fish caught per hour by our two stationary nets and the Avondale net.

Examination of this data shows that twenty-six species of fish were caught by these nets during the year. The maximum number of species taken any one month was seventeen. (June, west end; September, east end; December, Avondale.) The minimum recorded for any one month was ten. (October, east end; January, Avondale.) This qualitive distribution obviously does not correlate with the quantitative abundance, nor with the seasons.

Twenty-two species were taken by the west end net, twenty-one species by the east end net and nineteen by the Avondale net. Thus about the same number of species occupied the different sections of the Lake.

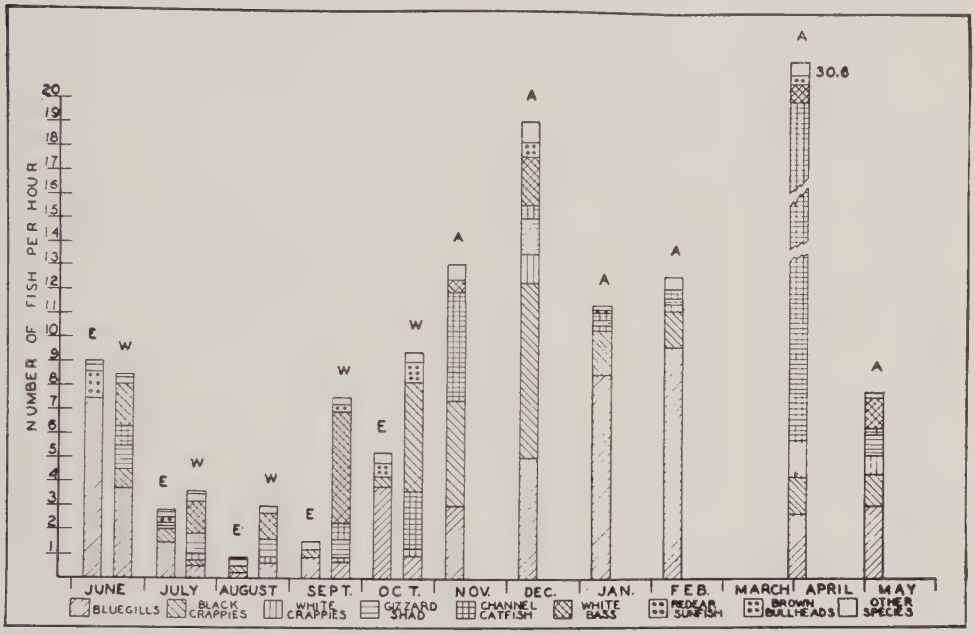

FIG. 1. Graph of fish catch by stationary and winter nets, showing average number of fish caught per hour through each month operated. (E, east end; W, west end; A, Avondale.)

Quantitative data show more correlations. The most noticeable of these is the decrease in catch per hour from June to August and a gradual rise from August to December. Under the heavy ice cover of January and February the catch dropped to about twelve fish per hour which, nevertheless, was several times greater than the mid-summer catch. The week following the ice break up the catch rose to an average of 38.0 fish per hour, of which 30.5 were channel catfish (*Ictalurus punctatus*). Spring catch decreased in 1940 to about eight fish per hour, a number corresponding to the number caught in the spring of 1939.

Bluegills (*Lepomis machrochirus*) were the dominant fish in the east end, catches ranging from 34 percent (August) to 83 percent (June) of the total number of fish taken. White bass (*Lepidema chrysops*) were the dominant fish in the west end catches (except in June when they were exceeded by bluegills) ranging from 26 percent of the total catch in June, to 62 percent in September.

The dominant species caught in the Avondale net from November, 1939, to May, 1940, varied. In November the dominants were black crappies (*Pomoxis nigro-maculatus*), making up 34 percent of the total catch, bluegills 25 percent and channel catfish 22 percent.

In December black crappies made up 43 percent, bluegills 31 percent and white bass 13 percent of the total number of fish caught.

In January bluegills totaled 75 percent and black crappies 15 percent of the total catch. This was almost duplicated by the February catch in which these two species made up 76 and 14 percent respectively of the total.

In March and April channel catfish made up 80 percent of the total catch. These were followed by white crappies, 6 percent, black crappies, 4 percent, and white bass, 2 percent.

Trap nets are thought to be selective as to species and numbers of fish caught. Fish with solitary habits or with a tendency toward cannibalism are not caught in as large numbers as are those of a more gregarious nature. The true ratio of fish species in a given body of water to the catch made by various types of nets needs yet to be worked out, although from some work I have done I do not believe the type of net used gives a picture of fish populations very dissimilar from the actual population. (Roach, 1940.)

However, if we consider the catch by these nets as roughly indicating comparative numbers we may say that bluegills are the dominant fish of Buckeye Lake. White bass are apparently the sub-dominants in the open portion of the Lake while black crappies fall into this position in the sections of abundant vegetation. White crappies (*Pomoxis annularis*) and brown bullheads (*Ameiurus n. nebulosis*) come in just one step lower as sub-dominants of the open water and vegetation sections respectively.

Channel catfish and largemouth black bass (*Huro salmoides*) are apparently adapted to both weedy and open situations although the bass tend toward the weedy portions and the catfish toward the more open areas.

Gizzard shad (*Dorosoma cepedianum*) were caught in all three nets each month but apparently preferred the more open situation.

The other species caught evidently have their own habitat niches, none of which are extensive enough to make them dominant species in Buckeye Lake. One species, the red-eared sunfish (*Lepomis microlophus*), caught in fair numbers in June and July by the east end net was not known in Buckeye Lake prior to 1934, at which time 57 breeders were stocked. During this survey 1,018 red-eared sunfish were taken so it seems reasonable to assume that the Lake has an environment suitable to their needs and that they may become a dominant species in time. This may be at the expense of some other species, possibly the bluegill.

Since data compiled from our stationary and winter nets indicate a considerable variation in the numbers and kinds of fish caught in a measured period of time, over different seasons and in different habitats, it seems apparent that little in the way of comparison can be made between the catches of 1930, 1938 and 1939–40 as far as actual number per hour is concerned. For example, nets set off Journal Island in July, 1930, caught 10.4 fish per hour; in June, 1938, 22.2 fish per hour; in June, 1939, 7.0 fish per hour. While it is evident that little comparison can be made between the quantity caught in the different years we believe it is safe to assume that there has been no appreciable decrease or increase in total numbers of fish over that period of time (1930 to 1939) since the variations that occur appear to be seasonal.

Figure 2 has been prepared to show the relative abundance of the species caught by the 1930 and 1938 preliminary survey nets and the 1939 roving net. Fish are graphed according to their percentage of the total catch.

The percentage of bluegills caught in July, 1930, compares favorably with the percentage caught in June of 1938 (60.8 and 58.0 percent respectively), while the percentage of bluegills caught in June of 1939 dropped to 41.3. This most certainly does not indicate a loss of bluegills in 1939 over 1930 or 1938, but it does show that June of 1939 was a slightly different month from June of 1938 or July of 1930.

This might be amplified by comparing the July, 1930, and June, 1939, percentages 60.8 and 41.3 respectively with the September, 1930, and September, 1939 percentages, which were 12.2 and 9.8 respectively. The difference between June and September percentages in the same year (e.g., 60.8 to 12.2) is noticeably more pronounced than the difference (e.g., 12.2 to 9.8) between the same months from 1930 to 1939.

Another example of this same situation was the catch taken at Journal Island. The percentage of white bass caught at Journal Island in September, 1930, was 72.0 and in September, 1939, 62.0. On the other hand, white bass in July, 1930, made up only 11.4 percent of the total fish caught as compared with 6.8 percent in June of 1938 and 26.0 percent in June, 1939.

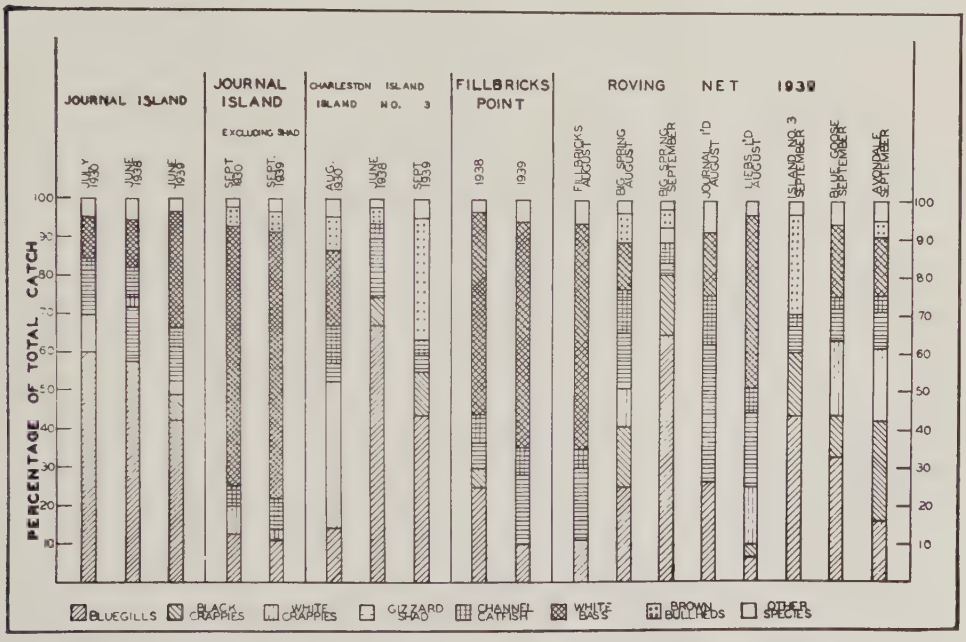

FIG. 2. Graph of fish catch in percentage of total number for 1930, 1938 and the roving net for 1939.

As has been indicated in an earlier paragraph, different environments also influence the percentages of the various species caught. For example, at Fillbricks Point (an open water situation) in August, 1939, only 9.7 percent of the fish caught were bluegills, whereas 61.3 percent were white bass and less than one percent was black crappies. At Big Spring Bay (a heavily vegetated area) one week later and still in August, 25.5 percent of the fish caught were bluegills, whereas 15.6 percent were black crappies and only 6.6 percent were white bass.

The only noticeable difference in the percentages of fish caught in 1939 as compared with 1930 occurred in the catch of black crappies which ran consistently higher in 1939. It is believed that these fish require a considerable amount of vegetation and clear water so the expansion of the vegetation area since 1930 might be an explanation.

GROWTH RECORDS

All fish were measured to the nearest quarter inch as they were caught. Since our stationary and Avondale nets were operated each month over a year we should

TABLE I

Buckeye Lake

Weighted Mean Length of All Species Caught in 1939 and 1940

Month	June		July		August		September		October		November	December	January	February	March and April	May
Location in Lake	East	West	East	West	East	West	East	West	East	West	Avondale	Avondale	Avondale	Avondale	Avondale	Avondale
Bluegill	6.3	6.7	6.4	6.8	6.0	6.9	6.4	7.1	6.5	7.2	7.2	7.3	7.4	7.0	6.9	6.9
Red-eared Sunfish	6.0	.....	6.1	.....	6.0	.....	6.4	.....	6.8	.....	6.1	7.1	7.1	7.2	6.2	.....
Pumpkinseed Sunfish	5.0	5.5	5.0	5.8	4.9	.....	5.1	.....	.....	.....	.....	.....	5.8	.....	.....	5.5
Hybrid Sunfish	6.0	6.0	.....	.....	.....	.....	5.2	.....	5.3	6.5	.....	.....	.....	.....	.....	.....
Green Sunfish	.....	.....	5.0	.....	5.5	.....	6.0	.....	.....	.....	.....	.....	.....	.....	.....	5.5
Long-eared Sunfish	.....	.....	6.2	.....	.....	.....	.....	.....	.....	.....	.....	6.5	.....	.....	.....	5.7
Rock Bass	.....	.....	.....	.....	.....	.....	.....	8.8	.....	.....	.....	.....	.....	.....	.....	.....
Black Crappie	7.4	7.9	7.5	7.9	7.2	7.3	7.9	7.8	8.1	7.5	7.4	8.2	7.5	8.0	6.3	7.4
White Crappie	.....	9.2	6.0	9.2	.....	8.3	9.2	9.3	.....	8.1	8.8	9.1	8.9	9.0	8.5	8.5
Largemouth Bass	11.8	17.2	7.8	19.4	8.1	16.4	8.0	14.1	8.3	.....	9.8	14.5	11.1	9.6	9.0	8.8
Smallmouth Bass	.....	12.2	.....	19.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
White Bass	.....	9.4	10.9	10.5	12.0	10.7	11.0	10.0	8.0	10.0	11.9	10.6	.....	.....	10.2	10.6
Chub Sucker	9.1	.....	8.3	.....	.....	.....	8.5	12.0	8.3	.....	9.0	.....	8.9	9.1	.....	9.3
Redhorse Sucker	11.9	.....	.....	.....	.....	.....	.....	17.1	.....	.....	.....	15.3	.....	.....	15.0	16.5
Common Sucker	.....	15.1	.....	14.8	.....	14.9	15.8	14.5	.....	13.1	14.7	7.5	.....	11.0	15.8	.....
Hog Sucker	.....	.....	.....	14.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Yellow Perch	.....	.....	.....	.....	.....	.....	.....	8.5	.....	.....	.....	.....	.....	.....	7.4	7.6
Channel Catfish	13.4	14.2	16.2	16.8	15.1	12.8	16.2	11.8	.....	11.7	10.5	10.9	10.1	10.6	9.4	9.4
Black Bullhead	10.0	10.1	10.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Brown Bullhead	9.8	10.6	10.1	9.5	9.9	11.4	10.0	10.8	10.0	10.7	10.1	10.4	9.9	9.7	9.1	9.8
Yellow Bullhead	8.2	.....	8.9	.....	8.5	.....	8.2	9.0	8.2	.....	8.8	6.8	.....	7.0	7.0	6.6
Golden Shiner	7.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.5	7.7
Gizzard Shad	11.0	10.8	12.7	10.9	10.8	10.8	10.9	10.9	13.1	10.5	10.8	10.9	11.0	11.0	11.0	11.4
Carp	24.3	22.0	19.0	21.2	23.3	24.2	29.0	22.6	.....	11.5	.....	15.8	.....	.....	23.8	.....
Quillback	.....	17.9	.....	.....	.....	17.4	.....	22.5	.....	20.5	.....	10.1	.....	.....	.....	.....
Walleye	.....	18.5	.....	.....	.....	19.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

be able to follow any variation in size of the same species by calculating their weighted mean length for each month. Comparisons of this type may also be made with the fish caught in a corresponding month and location during 1930 and 1938. I recognize that error of analysis might be introduced by this method, but I believe that examination of the distribution range should correct most of the error. Table I has been prepared to show the mean length of all species caught by our year around nets and Table II shows the mean lengths of the major species taken in 1930 and 1938.

Examination of these data indicates that the bluegills at Journal Island in July, 1930, averaged 7.38 inches in length but dropped to 6.77 in August of the same year. In June, 1938, at Journal Island the bluegills averaged but 6.4 inches in length. The decrease in average length of these fish from August to July in 1930 does not indicate a decrease in length of the fish caught but rather an influx of a young group that possibly, by August, had reached a size sufficient to be retained in the netting of the mesh size used in our traps.

TABLE II

Weighted Mean Length of Major Species

Place	1930 Journal Island	1930 Journal Island	1930 Charleston Island	1938 Fillbrick	1938 Journal Island	1938 Island No. 3
Month	July	August	September	June	June	June
Bluegills	7.38	6.77	7.66	6.5	6.4	5.8
Black Crappies	8.12	.....	.....	7.0	6.5	5.9
White Crappies	8.31	7.81	8.23	7.8	8.8	9.0
White Bass	10.48	10.08	11.62	8.3	9.1	.....
Channel Catfish	16.59	11.99	19.63	11.7	11.4	14.1
Brown Bullhead	11.58	10.66	11.60	.....	.....	.....
Gizzard Shad	.....	.....	.....	10.3	10.2	10.5
Carp	23.81	25.90	24.11	21.7	21.6	22.2

This is possibly better illustrated by the figures given in Table I. Bluegills from the east end net in June, 1939, averaged 6.3 inches, in July 6.4 inches and in August dropped to 6.0 inches (with an influx of small fish). However, in September they had again risen to 6.4 inches and by October, 1939, to 6.5 inches.

The 1939 catch of bluegills for the west end, on the other hand, indicated a steady increase in mean length. In June they averaged 6.7 inches, in July 6.8 inches, in August 6.9 inches, in September 7.1 inches, and in October 7.2 inches.

This difference might indicate that hatching and rearing conditions in the vegetated east end surpass those of the open west end and that this results in the east end producing unusual numbers of young which, however, would not make themselves felt in the west end until the population pressure of the east end became so strong as to cause a push resulting in a migration west.

The growth of white bass as shown by length frequencies and amplified by scale analyses, indicates that this fish lives but three years. It grows to about seven inches its first year, to between ten and eleven inches its second year and to about twelve and a half inches its third year. Most of the third-year group disappear during late fall, winter or early spring.

The variation or fluctuation of the mean length of other species from month to month is also noticeable. For example, the black crappies of the east end in June, 1939, averaged 7.4 inches, in July 7.5, in August 7.2, in September 7.9, and in October 8.1 inches.

It is generally considered by many fisheries biologists that the carrying capacity of fish in pounds per acre is fairly consistent over a period of years for the species the water contains. If the variations in average lengths of these fish is translated into average weights an explanation for the fluctuations might be had.

MANAGEMENT SUGGESTIONS AND SUMMARY

Trap nets of the fyke design were operated in Buckeye Lake for a year (June, 1939, to June, 1940). A gradual decrease in number of fish caught per net hour was noted from June to August and a gradual rise from September to December. Over ten fish were caught per net hour in January and February under a heavy ice sheet. This was over five times as many as were caught in August. Immediately after the ice thaw (late March and early April) over thirty-eight fish were caught per hour. The catch per hour in May, 1940, approached the June, 1939, catch. Bluegills were the most abundant fish, being caught in every net, every month, white bass, black crappies, white crappies, gizzard shad and channel cats were also numerous. Twenty-six species of fish were taken by our nets.

Distinct differences were noted in the catches of the net set in the open water of the west end as compared with the net operated in the vegetated east end. Bluegills and black crappies were dominants in the east end. White bass, white crappies and gizzard shad were the west end dominants.

Besides seasonal differences in our quantitative catches habitat, or environmental, differences were noted. A roving net was operated through August and September. The catch per hour with this net, set for a week at a time in different locations, varied from three to sixteen fish per net hour. The open water situations seemed to be more favorable for movement.

Nets of the same kind were operated in this Lake for three months in 1930 and on a preliminary survey for two weeks in 1938. Catch records in numbers of fish per hour show no differences that cannot be explained by seasonal or other local and temporary factors.

Catch records computed in percent of total for each species also indicate no material change within these years in ratio of species except that the increase in numbers of black crappies appears to be coincidental with the expansion of the aquatic meadows of the east end.

Since all fish caught by the nets were measured and marked, excellent growth records and changes in size groups are illustrated by the length frequencies.

It is apparent from the data offered that the length groups did not change materially between 1930 and 1939. At least differences were not greater than they were in the Lake at different spots in the same month during 1939.

Although no figures were presented in this paper relative to our shore seining, crappies, bluegills, and bass, young of the year, are always found in large numbers. Bass constitute up to forty-four percent of fish caught by seine, bluegills up to twenty percent and crappies up to fifteen percent at certain spots. Apparently spawning areas are sufficient.

As a result of these studies it is obvious that stocking does not materially effect the fish crop in the Lake. It is disheartening to buy 1,500 breeder channel catfish, truck them all the way from Lake Erie for a season's stocking when over 6,000 native channel cats were caught in one net in a six-day period with only one-tenth of one percent repeating after the fifth day and no repeats from this net taken in another net 100 yards away. It also seems folly to ship in two truck loads of hatchery bluegills when there are an average of 200 of them in each 100 feet of shoreline in many sections.

The numbers of white bass and crappies stocked in the past eight years have been negligible, yet all indications point to the fact that they have maintained their relative abundance and total numbers. In fact the black crappie has become

a dominant species with the development of a more suitable habitat. In 1934 fifty-seven red-eared sunfish, a species never before found in Buckeye Lake, was stocked in the Lake. Without additional stocking our nets indicate that there are now several thousand red-eared sunfish in Buckeye Lake.

In past years, sanctuaries for spawning activities were set aside to protect the breeder fish, yet more young of the year were observed in areas not included in sanctuaries. These areas could not be closed off because they fronted cottages, boat docks or swimming beaches.

Except for continuing an inventory check on supply and demand and mechanically controlling excess vegetation so more water will be available to fishermen, few suggestions for better fish management can be offered.

Nearly every species of fish in the Lake is of "catchable" kind. This fact plus the large size of the Lake makes it impractical to attempt to "balance" fish populations of the Lake by nets. Again, because of the Lake size, fertilizing would not be practical.

It is apparent that habitat "niches" are filled with adult fish, so additions of material such as gravel to increase spawning area defeats its own purpose in that only a certain number of fish can reach adulthood.

It also appears to be evident that fish removed by fishermen are quickly replaced from native stock coming on, therefore additional legal restrictions will only result in a decrease of fishermen pleasure and not in increased fish.

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Philosophy

A mathematician presents a philosophy which challenges the authority of mathematics. Naturally, he relys on a set of axioms as a foundation. However, not all of the axioms are easily grasped. In fact, the general reader will no doubt find the book vague and difficult reading and quit it even before reaching the third chapter where the 38 axioms are stated.

The fundamental criterion of truth set up is the understanding of the individual concerned. Thus "a statement may be true for one person, yet ambiguous, meaningless, or even false for another . . ." depending on their relative understandings and viewpoints. "Truth develops only with a developing viewpoint." A consistent viewpoint, together with a view, makes a concept. A concept is eternal, i. e., truth is absolute and never changes, yet it is *dependent* on the viewpoint.

The challenge to mathematics concerns the use of abstract symbols without regard to whether or not they have physical significance. Symbols for which one cannot develop a concept can have nothing to do with truth as this philosophy defines it.—*Elton F. Paddock.*

What is Truth?, by Glen H. Draper. 1941. Ransdell Incorporated, Washington, D. C. 122 pp. $0.00.

Counting Alpha and Beta Particles

The counting of charged particles is perhaps the most important single technique in the problems of nuclear physics. In the monograph "Electrical Counting," the author, W. B. Lewis, considers the methods developed to date in a rather complete fashion. A few pages at the beginning are devoted to the subject of ionizing chambers and are then followed by a well-written summary of the limitations of amplifiers. The bulk of the little book deals with the design of amplifiers and is not much different from the material that may be found in texts on radio. Unfortunately for American readers, the tubes mentioned are foreign. It would be a good idea if British and American authors gave the number of tubes with similar characteristics. Special attention at the end of the book is given to circuits for Geiger-Müller counters, the theory of randon distributions, coincidence counting, and the use of counters with screens for making energy determinations.

The book is well printed, but the paper is of wartime quality.—*J. B. Green.*

"Electrical Counting," W. B. Lewis. Cambridge University Press. 144 pages. $2.50.

THE CHALLENGE TO THE YOUNG SCIENTIST[1]

E. H. JOHNSON,
Kenyon College, Gambier, Ohio

In the present period of world-wide confusion it is difficult to trace the trends in human thinking and behavior that will prove dominant in the world of tomorrow. But undoubtedly we will agree at once that we are now entering a time of unprecedented need for all of the stabilizing influences that mankind has acquired during the centuries that are past.

Perhaps, first among these we should put the ethical and moral principles most clearly defined in Christianity, although it is true that there have been many other religions and philosophies which, though unacceptable to us, would, if universally followed, prevent any such mess as that in which most of the world is now involved. But however interesting these factors may be, the stabilizing agency to which I shall ask you to give a little thought this morning, is of much more recent development. I refer to the broad field of science.

The philosophies of science and religion have something in common. They both are systems for explaining the problems of existence. They are in agreement in that both presumably aim to be constructive. The true scientist does not have to be an atheist, and certainly he can not be a nihilist.

In contrast to religious or political arguments, all scientific questions can be settled or at least clarified by observation, calm and reasoned judgment, and unselfish thinking. And I believe that loyalty to these principles leads to loyalty to the governmental structure that fosters them. As a nation we are becoming involved in what may prove to be the greatest struggle of the ages, for it is between those who would fetter mind and body and those who would promote healthy growth. Each of us must decide which camp he will support. As scientists our choice should be an easy one to make, for science is necessarily democratic, and it requires an atmosphere of freedom if it is to survive, while the dictatorships are built on the principle of stifling freedom of thought and of action.

Now the scientific method demands a special kind of thinking, a habit of thought that will guide one's reasoning processes and actions. Science is more than a mere collection of facts; it is a philosophy of the universe. It means truth about existence. It is opposed to superstition. It has no room for wishful thinking. In the words of Bertrand Russell, "The kernel of the scientific outlook is the refusal to regard our own desires, tastes and instincts as affording a key to the understanding of the world."

It has been suggested that the scientific method is man's greatest discovery. We are still in the process of discovering it, for it implies a degree of discrimination that is far from common, even in so-called cultured circles. The word "science" comes from *scire*, to know, and its present meaning recalls another word, "sense," from *sensus*, to perceive. True perception leads to knowledge, or, as Francis Bacon expressed it, "knowledge is the daughter of experience, not of authority."

These facts are so well known to this audience that you smile at the mere mention of legislative bills proposing to make the value of "pi" equal to 3, or to aid aviation by repealing the law of gravity, but it is a sad fact that only a small part of the people in the world would see in these proposals anything to smile about. Surely, there is missionary work to be done. In fact, the task is so big, that I fear many generations of young scientists like yourselves will find it scarcely diminished. If progress is to be made, an aggressive campaign will be necessary;

[1]Annual Address, Junior Academy Section, The Ohio Academy of Science, Denison University, Granville, Ohio, April 18, 1942.

mere enthusiasm will accomplish little or nothing. But if you have acquired the scientific outlook, you will enjoy spreading the gospel of truth-seeking wherever you go, for you will be guided by scientific faith.

We will agree, then, I assume, that human progress is not to be advanced by mandate, and also that none of the worth-while qualities of civilization have been furthered by bullying.

It is quite generally admitted that the scientific method already has provided the possibilities for more comfort and happiness than now exist. Of course, there are a lot of people who must blame something or some one for all of the ills of the world. They see in technology only the tremendous forces that man has harnessed and turned to purposes of destruction. Now it should be quite evident, I think, that things in themselves are neither good nor bad; technology is neither moral nor immoral, it is amoral. Science means "sense," common sense (which, by the way, is far from common). But we *do* have to admit that a mere knowledge of the scientific way of life has not been sufficient to insure sane living. Unfortunately, the human machine has no built-in governor. Nevertheless, I believe that the potentialities for human betterment afforded by continued scientific progress, are practically without limit.

It may be that the suppression of the corrosive vandalism now spreading over the earth will necessitate a vast amount of additional destructiveness, but, unless we are ready to admit that life is only an ugly joke, and that we are foreordained from all time to be the victims of powers with purely malicious purposes, I see no reason to relinquish my own confidence in science and the scientific method as among the most promising agencies by which the world may be saved from a total relapse into barbarism. The outcome will depend entirely on the use mankind makes of the resources already within its grasp. You, who will be the scientists of the next few decades of the world's recovery and reconstruction, may actually be able to determine its course for centuries to come, for, as Anthony Eden has said, "from henceforth, *science* and statecraft must march together. Diplomacy, which has up till now, been the servant of higher strategy, must increasingly become the servant of science."

I could go on for a long time recounting the aspects of this thing we call "science." Perhaps each of us will best formulate for it his own definition, or, each of us may find it impossible to frame a definition that is sufficiently inclusive to be satisfactory. So let us take a moment to consider its major aspects about which we can agree.

Science requires co-operation. Its structure is based on consistency; it demands of its devotees, intellectual honesty; it trains them in the acceptance of realities; it kills superstition; it develops a critical mind that is not easily duped by gossip about nations or individuals; it is not something that can be monopolized by any man or group; it discourages the spread of inflamatory ideas; already it has increased the average span of human life; it is steadily developing new remedies for old ills and the new ones arising from the increasing complexities of interhuman relations; it is intolerant of mediocrity of thought or habit, but expands one's tolerance for the views of others; gradually it is strengthening man's grasp on the good things of life; in the long run, it is evolutionary, not revolutionary.

Scientific work always is connected directly or indirectly with human needs, and it is for this reason that it flourishes only in an atmosphere of freedom. The unique results of scientific discoveries are clearly evident when we compare them with those of military campaigns and political machinations. Undoubtedly the latter have some lasting and possibly beneficial effects, but it is only a matter of time before they may be undone and almost forgotten. As an example of this contrast, consider Napoleon's alteration of the map of Europe. It certainly was not permanent. On the other hand, Pasteur's researches continue to give new hope to millions who otherwise would perish miserably. Again, no one will

deny that there probably is a tremendous amount of activity in Germany at the present moment, and yet its constructive phases are largely for destructive purposes, and I venture to predict that the names of Bunsen, Helmholtz, Hertz, Koch and Ehrlich will be remembered gratefully centuries after the name of Hitler has been forgotten.

We need not linger long over a list of the tasks awaiting the men and women who are devoting their lives to the various specialized branches of science. All will share the urge to restore and raise higher than ever before the standards of living, to heal the wounds of the world, and enrich human life in what we hope will be a long, peaceful post-war period. Biologists will continue adding to our already considerable knowledge of life and death, health and sickness, and the innumerable factors in the plant and animal worlds will have an increasing bearing on man's future. The chemist will keep on adding to an endless list of new substances, foodstuffs and industrial materials. The past course of the physicist in learning to recognize and control the forces of nature, probably has set his feet on a long road of discovery of laws that will find vital application in all of the divisions of science. The psychologist will be able to point out many things concerning the behavior of the human animal that will make possible a helpful analysis of man's actions and enable him to avoid many of his past follies. The geologist readily admits that as yet we know only a little about the earth and its vast resources. His work is clear for decades to come. And it is the same with astronomy and mathematics and all of the arbitrary divisions of science including an ever-increasing number of specialized branches, many of which already have assumed the proportions of major subjects. In all of them there is more to be done, more to be learned, more reward to be gained.

Change has no merit in itself Sometimes the older things turn out to be the best. Science, like other constructive branches of human endeavor, must build on the acquisitions of the past. Life itself has been defined as a summation of experiences—one's own and the recorded experiences of others. Thus the richness of one's life is directly proportional to his appreciation of the world of which he is a part. If you question this assertion, just compare in your own minds for a moment the solitary confinement on a lonely island, say, of a Charles Darwin, with that of a similarly isolated person who has never acquired the enriching ability to see Nature in her manifold forms with an appreciation born of trained understanding.

This illustrates one of the chief functions of science in the school curriculum. It should enable one to enjoy an enlarged life because he has learned to keep the eyes of his mind open. Too many are like the woman, just returned from a trip through Europe, who was not sure whether she had been in Rome or not, because, as she explained, her husband had bought all of the tickets.

The attributes of a scientist may be summed up in two phrases—*conscious ignorance*, and *active curiosity* His rewards will depend on his *attitude* as well as on his *aptitude*. Although he, of all men, will find reasons for optimism, his life can never be one of complacency. "One must have chaos within," declared Zarathustra, "to enable one to give birth to a dancing star." In other words, he must be ever-mindful of the challenge awaiting him with each new dawn.

I hope that by this time each of you is asking himself: "What is the immediate challenge to me as an individual, and to the particular group gathered together here today?"

You are the productive scientists of tomorrow, the engineers, the laboratory technicians, the teachers, the men and women in whatever walk of life, who have acquired something of the scientific way of thinking. Some of you will be carrying on the work of the Senior Academies of Science in the years to come, not because it will bring you any money, but because you will be life-long true lovers of science. You may earn your bread and butter in ways not ordinarily classed as scientific,

but you will do your thinking scientifically, that is, with intellectual honesty, tolerance and altruism, because of the habits you now are forming as members of this Junior Academy of Science.

There is more truth than poetry in the statement that "as the twig is bent, so the tree will be inclined." In urging you to cling fast to the scientific way of life, I am not trying to sell anything, or advance any pet theory, for the cold facts add up to the single conclusion that this way of procedure has been constructive, while unscientific methods have been unproductive, if not actually destructive.

Junior Academies like this one, and science clubs in general, are apt to suffer during a period of world stress such as that we now are entering. In this sad respect they are no different from many organizations whose immediate aim is exclusively practical. Undoubtedly, the times ahead will try men's souls, and herein lies your greatest challenge, namely, to carry on for the sake of the brighter days that are sure to come, to enlist the co-operation of others for the good of the community life that must be reformed when the present destructive influences at last are subdued, to point the way of light and universal truth to a world half blinded by the smokes of its own burning temples.

Only a few years lie between today and the time when you will be called upon to be the scientific leaders, the legislators, the business managers, the teachers in a recuperating society. Whatever your political adherence, your church affiliation, your race, sex or physical characteristics, you cannot avoid the responsibility that will be thrust upon you, and I thoroughly believe that the course of the entire world may be influenced by groups such as this one, whose members have the courage to face the facts of life, the knowledge and honesty to use these facts for human betterment, and the intelligence to recall one of the real lessons of history, namely, that any other course has failed utterly to raise man above the level of the beasts of prey. And last, and most important of all, may you cherish the God-given sanity to realize unceasingly that yours is a trust. Your tools are sharp and two-edged, they may rebuild the world; they may destroy it. We who have been fortunate enough to gain a glimpse of how the world can be made a better place in which to live, must do all in our power to spread this gospel of constructiveness, to popularize the scientific attitude, in short, to take our places among the builders of the kind of world we want.

Please let me emphasize that in these remarks I am not for a moment advocating anything short of as well-rounded an education as may be obtainable. This is something to be pursued throughout life. It should include a generous appreciation of our rich heritage of culture in many fields. The scientist who has specialized in his chosen subject matter to the exclusion of the humanities is in as deplorable a state as the humanist who sees no cultural values in science. The educational process should be many-sided, for, in the words of Richard Gregory, education is the "deliberate adjustment of a growing human being to its environment." Now surely, training in the sciences provides an essential part of the equipment for this adjustment.

Under present war conditions, "education as usual" is no longer possible. This fact will complicate your own advanced scientific study. Discouraging delays will be unavoidable. But, inasmuch as you never will doubt the value of the constructive philosophy and practice of science, you will find that even the handicaps encountered in this distressing period, cannot make it other than a glorious experience. As time passes you will forget what your teachers have said in the classroom or laboratory. Perhaps you will not long remember that such a person as this or that particular teacher ever lived, but all the time your educational process has been going on, and its very essence is in the change it has produced internally in you as an individual. It is to be hoped that you have acquired a measure of healthy skepticism, a dominating and purposeful curiosity, a disciplined imagination, and the ability to meet and solve wholly new kinds of problems.

I believe that a fair degree of broad cultural training, including the sciences, is desirable in the development of a good citizen. We must cling to our knowledge of what constitutes decent standards for living with each other and the rest of the world, especially during this time of social and political turmoil. These ideals have been growing through the ages, and now, illuminated by the torch of science, they should help us to find the answers to the formidable questions with which we are confronted. If not, we will have to admit that we have been on the wrong track throughout the entire Christian Era.

If you scan the pages of social, political and military history, you will find in them principally a rather depressing account of mankind's mistakes and failures. But if you are seeking inspiration, you need only turn to the story of man as a builder, and this is largely contained in the history of his scientific growth and progress. Here is something that each of you can join in. Soon you will realize that you are a part of a long procession, headed by those humble creatures who first showed their fellows how to chip stone tools, and make fire, and construct shelters, and ultimately to build the roads that still are leading to new horizons. If you keep the faith you will be rewarded by ever-widening vistas of a land of great promise. And always, you will be in grand company.

Paleozoic Stratigraphy and Paleontology of the Appalachian Valley

The first part of this monumental treatise on the Paleozoic stratigraphy and paleontology of the Applachian Valley in Virginia contains 568 pages of descriptive text and illustrations. Fossil plates and accompanying explanations fill the 271 pages of the second part.

Charles Butts, the author, has spent the greater part of his long life in a patient and thorough study of the Paleozoic rocks from New York to Alabama. His work in Virginia has been prosecuted over thirty years, his first state report appearing in 1914 as Bulletin 9 of the Virginia Geological Survey. Bulletin 42, entitled, "Geologic Map of the Appalachian Valley in Virginia with Explanatory Text," which appeared in 1933, is his first major contribution to the interpretation of the Paleozoic stratigraphy of Virginia. The present two-volume Bulletin complements the Map and contains complete description of each formation shown therein. In addition, there is a brief description of the topography, and a discussion of the complicated structure and the geologic history of the region.

The stratigraphic treatment begins with the Lower Cambrian and ends with the Pennsylvanian (Pottsville). Approximately seventy formations and groups are recognized and described, and some of these are further subdivided. The scheme followed in the discussion of each formation includes name, limits, character, distribution, thickness, fossils, and correlations. In the more than four hundred pages devoted to stratigraphy there are forty-five plates which are largely reproductions of photographs of rock outcrops. In many instances a single plate shows three or four different views and all are reproduced splendidly. To many these illustrations will be helpful because they show the appearance of the different formations in surface exposures.

The Paleozoic record in Virginia is unusually rich and full. It is no surprise, therefore, to find in this volume, written by an eminent authority, a storehouse of invaluable material for students of the Paleozoic and others interested in the geology of the Southern Appalachians.

Besides the treatise on stratigraphy, Part One contains two other noteworthy sections. Thirty-three pages are given to the consideration of geologic structure, with typical sections. A number of very attractive plates showing photographs of unusual examples of major and minor structures greatly enhance the work. As an example, Plate 54, showing (a) wave-marks in Pocono sandstone, (b) cross-bedding in Pottsville sandstone, (c) mud-cracks in Moccasin limestone, and (d) joints in Moccasin limestone, would adorn any textbook on rock structures.

The last major section of Part One is a narration of the geologic history of the Appalachian Valley region in Virginia involving an erosional and a sedimentary record during the Paleozoic and the erosional record during post-Paleozoic time. This will appeal strongly to geologists who like to interpret rocks and fossils in terms of dynamic landscapes.

Part II is devoted exclusively to Fossil Plates and Explanations. There are 72 full-page plates which present a total of 1,980 fossils. The magnificent photographs are the work of Dr. Charles E. Resser of the U. S. National Museum. A high grade of book paper is used throughout for both plates and descriptions. The book is most attractive in its appearance.

These two volumes, along with Bulletin 42 by the same author, are a highly significant contribution not only to the geology of Virginia but also to the Paleozoic geology of North America. Even a general perusal of Bulletin 52 gives a geologist a good review of the sequence of Paleozoic formations and the evolution of Paleozoic life.—*Frank J. Wright.*

Geology of the Appalachian Valley in Virginia, by Charles Butts. Bull. 52, Parts 1 and 2, Virginia Geological Survey, University, Virginia, 1941 and 1942.

ADDITIONS TO THE ALGAE OF THE WEST END OF LAKE ERIE[1]

CLARENCE E. TAFT,
The Ohio State University

The algae of the west end of Lake Erie is exceptionally well known through the work of Tiffany who has contributed detailed reports on the plankton (1934) and filamentous (1937) forms. It has been the privilege of the writer to continue this work during the summers of 1938, 1940, and 1941, while a member of the staff of the Franz Theodore Stone Biological Laboratory at Put-in-Bay, Ohio.

Because of the extended period of collecting by Tiffany (1920–1936), and the thoroughness with which the collections were examined, few new forms have appeared in the writer's collections. Due to the importance of these previous reports to students of aquatic biology in the Island Region of Lake Erie, the writer feels that supplementary lists of unreported forms will be of value.

For a general discussion of the region, and particularly for the algal habitats involved, the reader is referred to either of the reports by Tiffany.

Although the number of previously unreported forms is not large, some relatively rare and interesting genera are included. Such genera as *Glaucocystis*, *Gloeochaete*, *Monocilia*, *Hyalobryon*, *Hemidinium*, and *Kentrosphaera* have seldom been collected from the United States. *Gloeodinium montanum* Klebs, *Coelastrum Bohlini* Schmidle and Senn, and *Trachelomonas bulla* Stein appear to be new records for the United States. The *Batrachospermum* which the writer has been unable to identify because of its immature condition is reported because it is the first member of the Rhodophyceae to be collected in the region.

Credit for collections made by members of the freshwater algae class during the summer of 1940 is given after the descriptions.

SPECIES LIST

Glaucocystis Nostochinearum Itz. (Pl. II, Fig. 2). Cells of the Oocystis-like organism ovoid, solitary or in colonies of 2–4–8 cells, each cell containing numerous, curved, rod-shaped, blue-green bodies which are considered to be members of the Myxophycean family, Chroococcaceae. Size of the Oocystis-like cells 11–12 x 18–21μ, of the colony 28 x 37μ.

Haunk's Pond, Middle Bass; Smith Pond, N. Bass; E. Harbor; Pelee.

Although never abundant, this relatively rare alga is widely distributed in the Island Region of Lake Erie. With the exception of the specimens collected in Fox's Marsh, Pelee Island, the dimensions are well within the limits of the species *Nostochinearum*. Those from Pelee Island have a diameter of 21μ and a length of 32–35μ.

Gloechaete Wittrockiana Lagerh. (Pl. I, Fig. 8). The four colorless cells of the Chlorophycean host are embedded within a broad hyaline envelope, and each cell bears a long gelatinous bristle. The cells of the endophyte which are brilliant blue-green in color occupy a region corresponding in shape and position to the cup-shaped chloroplast in cells of the Volvocales. The specific name *Gloeochaete* is restricted to the Myxophycean component of the association and is not applied to the Tetrasporine host. Cells of the host 13–16μ in diameter. Diameter of colony 45–50μ.

Epiphytic on colonies of Rivularia, Haunk's Pond, Middle Bass.

Plectonema Wollei Farlow (Pl. I, Fig. 3). Filaments long, not contorted; false branches few in number, usually single; sheath thick and slightly yellow when old, lamellated; cells discoidal, not constricted at the cross walls, dark blue green, end cells rounded. Filaments 42–60μ, sheath 5–10μ, cells 37–45 x 5–7μ.

Middle Isl., floating off shore in deep water; on *Chara sp.*, in 10 feet of water, Hatchery Bay.

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[1]Contribution from the Franz Theodore Stone Biological Laboratory, Put-in Bay, Ohio. Papers from the Department of Botany, The Ohio State University, No. 458.

Monocilia viridis Gerneck (Pl. II, Fig. 4). A more or less distinctly branched filament, filaments sometimes short and tending toward a palmelloid condition. Cells about 10–12μ in diameter, varying to 15μ in length, each with several discoid, parietal chromatophores.

Growing on old shells of Daphne ? in a muddy, contaminated pool on South Bass. Collected by E. G. Snyder.

Botrydium granulatum (L.) Grev. (Pl. I, Fig. 7). A terrestrial algae composed of a unicellular, multinucleate, globular structure above the surface of the soil, and a much branched, colorless rhizoidal system below. The diameter of the aerial portion may reach 2 mm.

On damp soil in vineyards, North Bass; Pelee.

Hyalobryon mucicola (Lemm.) Pascher (Pl. II, Fig. 5). Cells solitary, epiphytic on cells of *Fragillaria sp.:* receptacle extremely delicate, upper portion nearly cylindrical with a flaring mouth, lower portion conical and produced into a short stipe, growth rings appearing as minute denticulations. Protoplast ovoid, at base of receptacle, with two golden-brown chromatophores and two flagella of unequal length. Receptacle 4.6 x 23–28μ.

Hatchery Bay.

Because of its extremely small size and the superficial resemblance to individuals of *Dinobryon* colonies, this algae is easily overlooked. However, it is not to be confused with such individuals when its epiphytic habit and the presence of growth rings has been determined.

Hemidinium nasutum Stein. (Pl. II, Fig. 6). Cells ellipsoidal, strongly flattened, girdle incompletely encircling the cell.

Quarry pools, Kelleys Island. Collected by Miss Dorothy Clum.

Gloeodinium montanum Klebs. (Pl. I, Fig. 2). Cells large, nearly spherical, united in four-celled colonies by a common, concentrically stratified envelope, each cell also with a stratified envelope. Chloroplasts numerous, golden-brown, radially arranged, sometimes partially obscured by large amounts of starch and oily substances. Diameter of colony 69–74μ, diameter of cells 25–28μ.

Associated with members of the Chlorococcales and desmids on the wet surface of peat in Fox's Marsh, Pelee Island.

Oedogonium cyathigerum Wittr. (Pl. I, Fig. 5). Nannandrous, idioandrosporus; oogonia 1–2, subovoid, pore superior; oospore same shape as oogonium, filling it, median spore wall with about 16 longitudinal ridges; dwarf male goblet-shaped, curved; veg. cell 25–30 x 76–105μ; suff. cell 35–46 x 69–92μ; oogonium 55–71 x 64–80μ; oospore 54–69 x 62–74μ; dwarf male 13–16 x 57μ.

Wehrle Pond, Middle Bass.

Chlorochytrium biennis (Klebs) G. S. West (Pl. I, Fig. 9). Cells endophytic, in grass sheaths, ovoid, walls strongly stratified, with localized lamellated thickenings. Young cells green, old cells yellowish to brown. Size of cell 46–70μ.

Quarry pools, Kelleys Isl.

Kentrosphaera Bristolae G. M. Smith (Pl. I, Fig. 4). Cells solitary, free-living, intermingled with numerous genera of the Myxophyceae, cylindrical-elliptic; wall thick, lamellated, with one (sometimes numerous) localized thickening; chloroplast axial with numerous lobes. Diameter 23μ, length 83μ, thickness of wall 3–5.5μ.

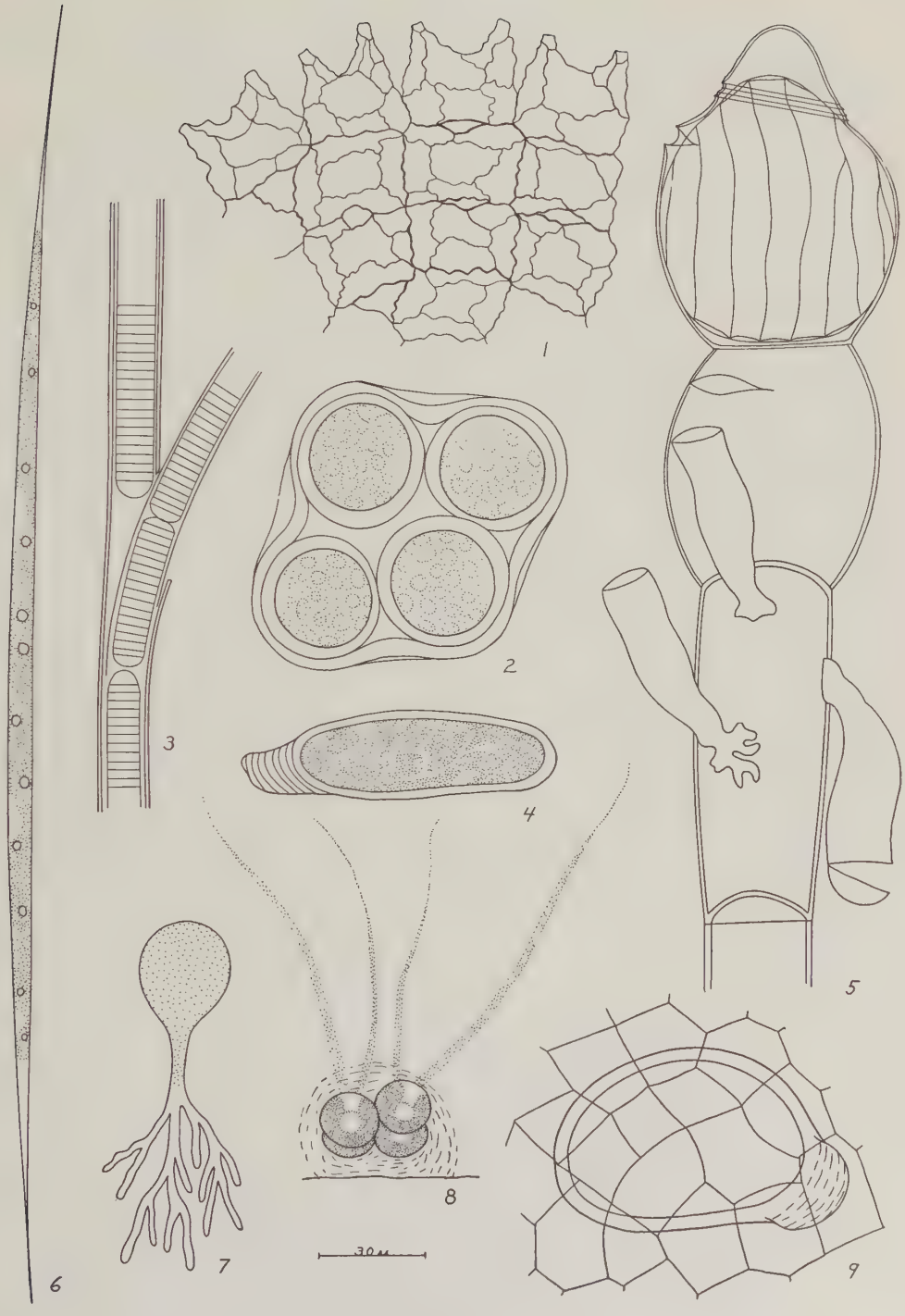
On moist soil in an abandoned quarry, Kelleys Isl.

Pediastrum angulosum (Ehr.) Men. (Pl. I, Fig. 1). Colonies large, circular, perforate; cell walls undulate; surface of cells with a coarse, undulate reticulum. Cells 18–25μ, colony 230μ.

East Harbor.

EXPLANATION OF PLATE I

Fig. 1. *Pediastrum angulosum* (Ehr.) Men.
Fig. 2. *Gloeodinium montanum* Klebs.
Fig. 3. *Plectonema Wollei* Farlow. Not drawn to scale.
Fig. 4. *Kentrosphaera Bristolae* G. M. Smith.
Fig. 5. *Oedogonium cyathigerum* Wittr.
Fig. 6. *Closteriopsis longissima* Lemm.
Fig. 7. *Botrydium granulatum* (L.) Grev. Not drawn to scale.
Fig. 8. *Gloeochaete Wittrockiana* Lagerh.
Fig. 9. *Chlorochytrium biennis* (Klebs) G. S. West.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30 μ

This form was first described as *P. angulosum* var. *araneosum* Racib., but has since been rejected as a valid variety by Bigeard, Rev. Algol. 7: 347, 1935.

Closteriopsis longissima Lemm. (Pl. I, Fig. 6). Cells solitary, acicular, with ends produced into setiferous apices; chloroplast single, often fragmenting, with 12 or more pyrenoids. Cells 7.5–9μ x 470–650μ.

Hatchery Bay.

The specimens from Lake Erie are large with their maximum dimensions well above those previously recorded. The species differs from the more common variety *tropica* W. and G. S. West because of its greater size as well as its setiferous apices.

Coelastrum Bohlini Schmidle & Senn (Pl. II, Fig. 1). Each cell with four ridges or flanges extending across the surface, 9–12μ in diameter; colonies somewhat irregular, about 27μ in diameter.

Quarry pools, Kelleys Isl.; Smith Pond, N. Bass.

The material compares well with the figure given by Schmidle in his 'Susswasseralgen" (1898).

Tetraedron siamensis (W. and G. S. West) Wille (Pl. II, Fig. 3). Cells solitary with a strongly convex outer surface and a slightly concave inner surface, ends produced into stout, usually curved spines. Size of cell 25–28 x 55–65μ.

Haunk's pond, Middle Bass.

Euglena tripteris (Dry.) Klebs (Pl. II, Fig. 7). Cells 14–103μ, elongate, band-like, spirally twisted, anterior end rounded, posterior end with a long colorless spine; periplast longitudinally striate; not metabolic.

Terwilliger's, S. Bass; Fisher Pond, Middle Bass.

Phacus torta (Lemm.) Skvortzow (Pl. II, Fig. 8). Cells 37–44 x 74–87μ, ovoid, with an elongate posterior spine, strongly twisted; periplast longitudinally striate.

Terwilliger's; Kelleys Isl.; Fisher Pond, Middle Bass; Smith Pond, N. Bass.

Lepocinclis fusiformis (Carter) Lemm. (Pl. II, Fig. 9). Cells 30–35 x 35–51μ, broadly ellipsoidal, somewhat pointed at either pole; periplast firm, spirally striate.

Mound pond, N. Bass.

Trachelomonas armata (Ehr.) Stein var.? (Pl. II, Fig. 13). Lorica 35–37 x 46μ, ovoid, poles rounded, pore with a very short collar; wall with spines of variable length around the poles, median part of wall smooth.

Fisher pond, Middle Bass.

Trachelomonas bulla Stein emend, Deflandre (Pl. II, Fig. 14). Lorica ovoid, irregularly and finely granulate; pore small; collar large, margin finely denticulate. Chromatophores numerous, discoid. Length including collar 29–32μ, length without collar 25–26μ, width 18–23μ.

Collected by E. G. Snyder from a small contaminated pond on South Bass. The dimensions are somewhat less than those given by Deflandre, otherwise similar.

EXPLANATION OF PLATE II

Fig. 1. *Coelastrum Bohlini* Schmidle and Senn.
Fig. 2. *Glaucocystis Nostochinearum* Itz.
Fig. 3. *Tetraedron siamensis* (W. and G. S. West) Wille.
Fig. 4. *Monocilia viridis* Gerneck.
Fig. 5. *Hyalobryon mucicola* (Lemm.) Pascher.
Fig. 6. *Hemidinium nasutum* Stein.
Fig. 7. *Euglena tripteris* (Dry.) Klebs.
Fig. 8. *Phacus torta* (Lemm.) Skvortzow.
Fig. 9. *Lepocinclis fusiformis* (Carter) Lemm.
Fig. 10. *Trachelomonas lacustris* Drezepolski.
Fig. 11. *Trachelomonas girardiana* (Playfair) Deflandre.
Fig. 12. *Trachelomonas volvocina* Ehr.
Fig. 13. *Trachelomonas armata* (Ehr.) Stein var.?
Fig. 14. *Trachelomonas bulla* Stein *emend.* Deflandre.
Fig. 15. *Entosiphon sulcatum* (Duj.) Stein.
Fig. 16. *Anisonema acinus* Duj.

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30 μ

Trachelomonas girardiana (Playfair) Deflandre (Pl. II, Fig. 11). Lorica 23–27 x 42–57μ, subhexagonal in front view, sides retuse, and end view circular; collar elongate and variable in length, oblique in optical section; wall granulate.

Squaw Harbor, South Bass; Smith pond, N. Bass.

If Deflandre (1930) is followed, this form should be *Strombomonas girardiana* (Playfair) Deflandre.

Trachelomonas lacustris Drezepolski (Pl. II, Fig. 10). Lorica 11–21μ, cylindrical, sides parallel, ends rounded; wall densely punctate; pore with a very short collar.

Smith pond, N. Bass.

Trachelomonas volvocina Ehr. (Pl. II, Fig. 12). Lorica spherical, 15–18 x 15–18μ in diameter, smooth, light yellow; pore without a collar.

Mound pond, N. Bass.

Anisonema acinus Duj. (Pl. II, Fig. 16). Cells 13–15 x 37–40μ, oval in outline with the anterior end somewhat narrower, end view compressed, with a longitudinal furrow extending from the insertion of the flagella to the posterior end; wall smooth; swimming flagellum about as long as the cell, trailing flagellum longer.

Quarry pools, Kelleys Isl.; Fisher pond, Middle Bass.

Entosiphon sulcatum (Duj.) Stein (Pl. II, Fig. 15). Cells 16–18 x 20–21μ, ovoid, slightly compressed, longitudinally furrowed with six (to twelve) grooves, grooves evident at anterior end; two flagella, the shorter swimming flagellum directed forward, the longer or trailing flagellum directed backward.

Mound pond, N. Bass. This species has been reported from East Harbor by Walton (1915).

Batrachospermum sp. This is the first recorded genus of the Rhodophyceae from the Island region. Although not identified as to species it is interesting because of the habitat from which it was collected.

Collected by W. A. McLane from shells of snails living in Fox pond, N. Bass.

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